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CONVERSATIONS

ON

VEGETABLE PHYSIOLOGY;

COMPREHENDING THE

ELEMENTS OF BOTANY,

WITH THEIR

APPLICATION TO AGRICULTURE.

BY THE AUTHOR OF

"CONVERSATIONS ON CHEMISTRY," AND "NATURAL PHILOSOPHY."

ADAPTED TO THE USE OF SCHOOLS,

BY REV. J. L. BLAKE, A. M.

FOURTH AMERICAN EDITION,

WITH ENGRAVINGS.

844712.
17. 6. 30.

PHILADELPHIA:

E. L. CAREY & A. HART—CHESNUT STREET;

BALTIMORE:

CAREY, HART, & CO.

1835.

DISTRICT OF MASSACHUSETTS, to wit:

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BE IT REMEMBERED, that on the seventeenth day of May, A. D. 1830, in the fifty-fourth year of the Independence of the United States of America, CROCKER & BREWSTER, of the said District, have deposited in this office the title of a book, the right whereof they claim as Proprietors, in the words following, *to wit:*

"Conversations on Vegetable Physiology; Comprehending the Elements of Botany, with their Application to Agriculture, by the author of "Conversations on Chemistry," and "Natural Philosophy." Adapted to the use of Schools, by Rev. J. L. Blake."

In conformity to the act of the Congress of the United States, entitled, "An act for the encouragement of learning, by securing the copies of maps, charts and books, to the Authors and Proprietors of such copies, during the times therein mentioned;" and also to an act, entitled, "An act supplementary to an act, entitled, An act for the encouragement of learning, by securing the copies of maps, charts and books, to the authors and proprietors of such copies during the times therein mentioned; and extending the benefits thereof to the arts of designing, engraving, and etching historical, and other prints."

JOHN W. DAVIS,
Clerk of the District of Massachusetts.

"We transfer to Messrs. CAREY & HART, all our interest in the within named work." Signed, CROCKER & BREWSTER.

Boston, June 27, 1833.

PREFACE.

When the editor was engaged in teaching he found insuperable objections to the study of Botany with his pupils, from the long catalogue of scientific names with which the elementary treatises on that subject were mostly made up. The common method of studying Botany in our schools has ever appeared to him absurd, imposing on scholars, a most burdensome drudgery, and calculated to create perfect abhorrence for that branch of knowledge. He considers it nearly as absurd as it would be to give the student in history a catalogue of all the emperors, kings, dukes, &c. from the creation of the world to the present time, to be carefully committed to memory in chronological order. Who could endure the sight of such a monstrous array of arbitrary names; or who would have the memory and resolution to perform such a task! But place before the student a judicious work on history, prepared as such works usually are, and the study becomes a most useful and delightful one. The names of distinguished individuals are learned, from their connexion with the various events of history, as there is occasion to know them. They are made familiar without effort, and, as it were, without a single thought upon the subject.

Another illustration of the absurdity of the common mode of studying Botany may be given. What would be thought of the wisdom or the practicability of committing to memory in alphabetical order the names from a Directory of all the individuals belonging to a city like New York, Philadelphia, or Boston? The project would be thought ridiculous? But let a person moving into one of these cities engage in business and he will very soon, as a matter of course, become acquainted with the inhabitants, from his daily intercourse with them, at least, so far as there is need of acquaintance. In this way students should learn Botany. Commence with vegetable physiology and the scientific names will occur, one at a time, as he passes along, till the whole are made familiar. On this plan is the work now presented to the public.

J. L. BLAKE.

Boston 12*th May*, 1830.

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CONVERSATIONS.

CONVERSATION I.

Emily. As I wander over these beautiful mountains, and observe the variety of flowers they produce, how much I regret my ignorance of botany !*

Mrs. B. It is, certainly, a science particularly adapted to Switzerland; but why should you suffer your regret to be vain? To wish to learn is the first, and often the most difficult step towards the acquisition of knowledge.

Emily. I should certainly like to understand botany, but I have no wish to learn it: there is such a drudgery of classification to encounter, before one can attain any proficiency to recompense one's labours, that I confess I do not feel courage to make the attempt.

Caroline. And, after all, what is it one acquires?—A knowledge of the class in which a flower is to be placed, according to the number of its stamens or its pistils; and, perhaps, after hard study, one may go so far as to ascertain its Latin name, though you may still be ignorant how it is called in your own vulgar tongue. Botany appears to me a science of rules and names, not of ideas; and is,

* The term Botany derives its name from the Greek word ***botane,*** which signifies an herb, or grass. This word may be easily traced to ***boo*** or ***bosko,*** to feed; and, since plants have ever been regarded as the food of a large portion of animals, the aptness of its derivation is apparent.

1.—To what place does Mrs. B. consider the science of Botany particularly suited ? 2.—What does she say is the first and often the most difficult step towards the acquisition of knowledge ? 3.—Why has Emily no wish to learn Botany ? 4.—How does Botany appear to Caroline?

therefore, devoid of interest. I am, for my part, quite contented to gather a sweet-smelling nosegay of beautiful garden monsters, as botanists denominate them, without troubling myself about their scientific names.

Mrs. B. I will frankly own, that, for many years, I entertained the same prejudices against botany, if such you will allow me to call them; but having had the good fortune, during a spring I passed at Geneva, to hear a course of lectures on that science by Professor De Candolle, I was entirely converted; and I am fully persuaded that no natural science is dry, unless it be drily treated. If people will attend more to the frame than to the picture which it contains, and if they will even cut and disfigure the picture, in order to make it fit into the frame they have prepared for it, no wonder that the subject should lose its interest.

Emily. None can be more likely to succeed in converting others, than those who have been converted themselves; and if you would indulge us, my Dear Mrs. B., with relating what you learnt at these lectures, I make no doubt that Caroline would be tempted to listen to you, were it but from curiosity to discover whether her first opinions on the subject were correct, or whether she ought not, at least, to acknowledge that they were hastily formed.

Caroline. Oh, I shall be very thankful to be allowed to remain, provided I am at liberty to depart if I find I do not take an interest in the study.

Mrs. B. I shall not be ambitious of retaining uninterested listeners: and though I was delighted with the instruction I received myself, I am very sensible that I shall not be able to communicate to you either the same degree of pleasure or of information. I will, however, do my best to relate to you what I can recollect of these lectures.

Mr. De Candolle, so far from confining himself to the classification of plants, examines the vegetable kingdom in its most comprehensive and philosophic point of view. In describing the structure he investigates the habits and properties of plants, and shows, not only how wonderfully

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5.—How did Mrs. B. have her prejudices against the science removed? **6.**—Of what is she persuaded in regard to natural science? **7.**—What illustration does she make with the picture and its frame? **8.**—How does Professor De Candolle examine the vegetable kingdom? **9.**—In describing its structure how does he proceed?

they have been formed to answer the purposes of their own multiplication and preservation, but how admirably they answer the higher purpose which Nature has assigned them, of ministering to the welfare of a superior order of beings—the animal creation; and more especially to that of man. He turns his attention particularly to point out the means by which the science of botany can promote that with which it is most intimately and importantly connected—agriculture. He prepares the soil and sows the seed for the husbandman; he extracts the healing juices and the salutary poisons for the physician; he prepares materials for the weaver, colours for the dyer; in a word, as he proceeds there is scarcely an art on which he does not confer some benefit, either by pointing out a new truth, or warning against an ancient error. Thus, throughout his course, his principal aim is to promote, by his vast stock of knowledge, the welfare of his fellow-creatures.

Emily. Treated in this point of view, botany cannot, I think, fail to interest us.

Mrs. B. It is rather the physiology of botany which I propose teaching you; and I shall merely give you such an insight into classification as is necessary to enable you to understand the structure and character of plants.

Mr. De Candolle entered upon the subject by observing, that, in classing the various productions of Nature, the first great line of demarcation is that which separates the mineral kingdom from organised beings. How would you make the distinction?

Caroline. Nothing more obvious: organized beings have life, and minerals have not.

Mrs. B. Very true; yet I should be tempted to retort upon you, that this distinction is rather of names than of ideas. I believe I have before observed to you, that we know not what life is. We see its effects: they are sufficiently apparent and numerous; and it is only by

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10.—To what does he particularly turn his attention in doing this? **11.**—What illustration is made showing how much Botany is connected with the arts? **12.**—What was his principal aim? **13.**—What part of the science does Mrs. B. propose teaching? **14.**—In classing the various productions of nature, what is the first great line of demarcation mentioned by the professor? **15.**—How does Caroline make this distinction? **16.**—What does Mrs. B. say of life? **17.**—What does she say in illustration of the distinction of Caroline between minerals and organized beings.

studying these effects that we are able to form any idea of that state of being which we call life. The first distinction, therefore, to be made between minerals and beings endowed with life is, that the latter are formed with organs adapted to fulfil the several functions for which they were destined by Nature. These organs differ, not only in form and structure, but more or less in the materials of which they are composed: organized beings are generally of a smooth surface, rounded, and irregular; whilst minerals are rough, angular, and in their crystaline state of geometrical regularity.

One of the principal functions these organs have to perform is nutrition. Unorganized matter may, in the course of nature, be enlarged or diminished, either by mechanical or chemical changes; minerals may be augmented by the addition of similar particles, or by chemical combination with substances which are dissimilar, but they have no power to convert them into their own nature.

Organized bodies, on the contrary, are increased in size, by receiving internally particles of matter of a nature different from their own, which they assimilate to their own substance.

Emily. That is to say, that the food by which they are nourished is converted into their own substance?

Mrs. B. Yes; organized beings have also the power of reproducing their species:—minerals may be broken into fragments, but they are alike incapable of receiving nourishment, of growing, or of reproducing.

Let us now proceed to inquire, what is the principal distinction between the two classes of organized beings, the animal and the vegetable creation.

Caroline. Animals are endowed with the power of locomotion, whilst vegetables are attached to the soil.

Mrs. B. It would, perhaps, be more philosophical to begin by ascertaining the cause whence this difference arises. Animals are provided with a cavity called a

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18.—What comparison does she make between minerals and organized beings, so far as their form and surface is considered? 19.—How is change of state in unorganized matter produced? 20.—What is said of organized beings, so far as change of state is considered? 21.—What other power have organized beings which does not belong to minerals? 22.—To what inquiry does Mrs. B. next proceed? 23.—What does Caroline consider the principal distinction between animals and vegetables? 24.—What does Mrs. B. think would be more philosophical?

stomach, in which they deposit a store of food, whence they are continually deriving nourishment. This organ is essential to animals as they are not constantly supplied with food: they find it not always beneath their feet; they must wander in search of it; and were they not furnished with such a storehouse, in which to lay it up, they would be frequently in danger of perishing.

Emily. Are we, then, in want of continual nourishment? And should we die if our stomachs were quite empty?

Mrs. B. No, not immediately; for though the system requires constant renovation, Nature is so careful of our preservation, that she not only affords us the means of subsistence, but provides resources in case of accidental interruption of the supply: after having consumed, or rather, I should say, assimilated the food contained in the stomach, the fat of animals is made to contribute to the nourishment of their organs, and the support of life. In some, such as the dormouse and the polar bear,* this provision is carried to such an extent, that they pass several of the winter months in a state of inanition; during which period, the only sustenance their system receives is from the abundant provision of fat which they had made during the summer; and when they are roused from their lethargy by the return of spring, they are lean and ravenous. The food of animals is conveyed from the stomach to the various parts of the body by the function which is called *digestion.* The food passes through small absorbent vessels into the blood, and is thence circulated throughout the system.

Caroline. But, Mrs. B., one would think you were going to give us the history of the animal rather than the vegetable creation.

Mrs. B. Only so far as to enable me to point out the distinction between them.

* The under part of the paws of the bear is composed of glands, which are at that time full of a white milky juice, and during his confinement he is said to derive considerable nourishment from sucking them.

25.—Why is it needful that animals be furnished with a stomach? 26.—If animals continually require nourishment, why do they not die, as soon as all the food in the stomach is assimilated? 27.—What is said of the dormouse and the polar bear? 28.—*What is said of the bear in the note?* 29.—How is the food of animals conveyed to the different parts of the system?

Vegetables have no stomach; they do not require such a magazine, since they find a regular supply of nourishment at the extremity of their roots: with them, therefore, there is no occasion for accumulation. In order to conceive an idea of the form in which plants receive nourishment, you must represent to yourself a very delicate cobweb network, of such extreme tenuity as to render it invisible until the interstices are filled and distended by the nutriment lodged within them. The food of plants is not like that of animals, of a complicated nature; but consists of the simplest materials,—water, and the solid and gaseous matter contained within it.

The second distinction between the animal and vegetable creation is, that the latter are not endowed with sensibility.

Emily. But the mimosa or sensitive plant, Mrs. B., when it shrinks from the touch, wears a strong appearance of sensibility.

Mrs. B. Yet I should doubt whether it is any thing more than appearance. Some ingenious experiments have, indeed, been recently made, which tend to favor the opinion that plants may be endowed with a species of sensibility; and seem to render it not improbable that there may exist in plants something corresponding with the nervous system in animals.

Caroline. The sensitive plant would then, no doubt, be a nervous fine lady at the court of Flora. But, pray, of what nature were these experiments?

Mrs. B. There are certain vegetable poisons, such as nux vomica, laurel-water, belladonna, hemlock, and several others, which are known to destroy life in animals, not by affecting the stomach, but merely by acting on the nervous system. These poisons were severally administered to different plants, either by watering them with or steeping their roots in infusions of these poisons. The universal effect was, to produce a sort of spasmodic ac-

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30.—Why have vegetables no need of a stomach? 31.—What is necessary in order to conceive how vegetables receive nourishment? 32.—Of what does the food of vegetables consist? 33.—What is the second distinction between the animal and vegetable creation? 34.—What objection does Emily make to this distinction? 35.—What do some ingenious experiments tend to show, to which Mrs. B. alludes? 36.—What were these experiments?

tion in the leaves which either shrunk or curled themselves up; and, after exhibiting various symptoms of irritability during a short time, became flaccid, and the plant in the course of a few hours died.

Emily. I should have been curious to have seen an experiment of this nature tried on the sensitive plant.

Mrs. B. It was done. Two or three drops of prussic acid, which, you know is a most powerful poison, were poured upon a sensitive plant: the leaflets closed and opened again at the end of a quarter of an hour; but they did not regain their sensitiveness for at least six or eight hours. When we see plants thus acted upon by vegetable poisons, which are known to be incapable of destroying the animal fibre, or of injuring the frame but through the medium of the nerves, we may be led to suppose, that certain organs may exist in plants with which we are totally unacquainted, and which bear some analogy to the nervous system in animals.

It is certain that plants possess the power of irritability or contractibility; for it is by alternate contractions and dilitations of the vessels that they propel the juices which rise within them. Here is a slip of elder: when I cut it in two, the fluid continues oozing from both of the separated parts; were there no action going on within the stem, only a single drop would flow out at each orifice. There are some flowers, such as those of the Barberry, whose stamens will bend and fold over the pistil, if the latter be pricked with a needle; and there is one instance of a plant whose leaves move without any assignable cause: this is the *Hedysarum gyrans*, which grows only on the banks of the Ganges; it has three leaflets on each footstalk, all of which are in constant irregular motion.

Emily. I recollect seeing a plant called Sundew, (*Drosera,*) the leaves of which, near the root, are covered with bristles bedewed with a sticky juice. If a fly settles on the upper surface of the leaf, it is at first detained

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37.—What was the effect of them? 38.—On the sensitive plant what experiment was made? 39.—What does Mrs. B. in view of these experiments, think we may be led to suppose? 40.—How are the juices in plants made to rise? 41.—What experiment is made with the slip of elder? 42.—What is said of the Barberry and some other flowers of a similar description? 43.—And of *Hedysarum gyrans?* 44.—What account does Emily give of a plant called *Sundew?*

by this clammy liquid, and then the leaf closes, and holds it fast till it dies.

Mrs. B. The *Dionea mascipula* affords another example of the same kind: it grows in the marshes of South Carolina. Its irritability is so great, that an insect which settles on it is generally crushed to death by the collapsing of the two sides of the leaf, which, like that of the Drosera, is armed with bristles.

Caroline. But all plants are endued with some degree of irritability, if you will not admit of sensibility; for we know that, in general, their leaves turn towards the light, and when growing in a room, they spread out their branches towards the windows, as if they were sensible of the benefits they derived from light and air.

Mrs. B. Light and air conduce to their well-being, and they are so wisely constructed by Providence as to seek them; but it is independently of all choice or preference. We must consider plants as beings in which the principle of life is reduced to its state of greatest simplicity. As we advance in the scale of creation, we find that the lowest animals are directed by instinct; intelligence increases as we approach towards man, who is guided by reason: but the vegetable world is influenced merely by physical causes, which derive their energy from the principle of life.

Emily. But since plants are so inferior in the scale of existence, why is their form so much more delicate and beautifully varied than that of animals? Is it not singular that Nature should be most solicitious for the appearance of her simplest works?

Mrs. B. The most curious details of the structure of a plant are visible in its outward form; whilst those of the animal economy are concealed in the anatomical structure of the internal parts. The organs of plants are chiefly external, and are ornamental at the same time that they perform the several functions for which they were formed.

45.—Is any other example of the same kind mentioned? 46.—What is it? 47.—What does Caroline say of the branches of plants growing in a room? 48.—What does Mrs. B. say in reply? 49.—How is the principle of life in plants to be considered? 50.—How is the case varied as we advance in the scale of creation? 51.—What question is proposed by Emily in relation to a seeming inconsistency in Nature? 52—What is Mrs. B.'s reply?

Plants appear, also, to be susceptible of contracting habits: the mimosa, or sensitive plant, if conveyed in a carriage, closes its leaves as soon as the carriage is in motion, but after some time it becomes accustomed to it, the contraction ceases, and the leaves expand; but if the carriage stops for any length of time, and afterwards recommences its motion, the plant again folds its leaves, and it is time only which can reconcile it to its new situation.

Emily. This evinces strong symptoms of sensibility. One would suppose that the plant was alarmed at the new and unknown state of motion; and that its apprehension, like that of an infant, returned every time the novelty recurred.

Mrs. B. You will, perhaps, consider plants as patriotic, when you learn that those which are brought from the southern hemisphere, faithful to the seasons of their native country, make vain attempts to bud and blossom during our frosty winter, and seem to expect their sultry summer at Christmas.

Caroline. If you continue thus, Mrs. B., you will certainly make me think that plants are not wholly devoid of sensibility.

Mrs. B. We cannot positively deny it; but the evidence against that opinion is so strong as to amount almost to proof. Had providence endowed plants with the sensations of pleasure and of pain, he would, at the same time, have afforded them the means of seeking the one and avoiding the other. Instinct is given to animals for that express purpose, and reason to man; but a plant rooted in the earth is a poor, patient, passive being: its habits, its irritability, and its contractibility, all depending on mere physical causes.

The properties of plants may be separated into two classes: first, those which relate to their structure; such as their elasticity, their hygromatric power: these prop-

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53.—What account is given of the *mimosa* when conveyed in a carriage? 54.—What is the remark of Emily on it? 55.—What is stated of plants brought from a southern to a northern hemisphere? 56.—Had Providence endowed plants with the sensations of pleasure and pain, what else would he have afforded them? 57.—What is the difference between animals and vegetables, so far as this purpose is considered? 58.—Into how many classes may the properties of plants be divided, and what are they?

erties may continue after death. Secondly, those which relate to their vitality; such as contractibility: which, consequently, can exist only in the living state.

The organs of vegetables are all composed of a membranous tissue, which pervades the whole of the plant; they are distinguished by the name of elementary, and are of three kinds.

1st. The cellular system, consisting of a fine tissue of minute cells or vesicles, of a haxogonal form, apparently closed and separated by thin partitions, somewhat similar to the construction of a honeycomb; or bearing, perhaps, a still nearer resemblance to the bubbles formed by the froth of beer.

Emily. This appears very similar to the cellular system in the animal economy, which you described to us in our lessons on Chemistry.

Mrs. B. One of the chief purposes of the cellular system in the animal frame is to contain the fat, a substance to which there is nothing analagous in the vegetable kingdom.

These cells in plants, are marked by small spots, which have been conjectured to be apertures through which fluids are transmitted from one cell to another; but these marks are so very minute, as to render it hazardous to venture on deciding for what purpose they are designed.

Caroline. If it is the cellular system which transmits the sap, it should with more propriety be compared to the veins and arteries of animals. But are not plants furnished also with a vascular system?

Mrs. B. Yes; and this forms the second set of elementary organs. It consists of tubes open at both ends: these are always situated internally, and are, besides, guarded from injury by being lodged in a thick coating of the cellular integument. Some of these vessels assume the form of a necklace, their coats being at intervals drawn tight together, or strangulated, so as to appear to stop the passage of the fluid they contain.

59.—Of what are the organs of vegetables composed; how are they distinguished; and of how many kinds are they? 60.—How may the first kind be described? 61.—For what purpose is the cellular system in animals? 62.—What is said of the cells in plants? 63.—What does Caroline call the second set of elementary organs? 64.—Of what do they consist, and how are they described?

Caroline. It is doubtless through the vascular system that the sap rises?

Mrs. B. The organs of plants are so extremely small, that, though aided by the most powerful microscope, it is frequently difficult to examine the structure of their parts with a sufficient degree of accuracy to be able to ascertain their functions. It has long been a disputed point, whether the sap ascended through the vascular or the cellular system of organs; but the latest opinion, and that which Professor De Candolle is inclined to favor, is, that it passes through neither; and that it rises through interstices which separate the different cells.

Emily. Indeed! It seems to me very extraordinary that the sap, which performs so essential a part in the economy of vegetation, should not flow freely through appropriate vessels, but be left to find its way as it can between them.

Mrs. B. The sap, when first pumped up by the roots, consists of little more than water, holding various crude materials in solution; it is, therefore, more important that the regular organs should be reserved for its elaboration, and its conveyance after that process, to the several parts of the plant.

The third system of elementary organs is the trachæ;* so called from their conveying air both to and from the plant: they are composed of very minute elastic spiral tubes.

Caroline. But, surely, plants do not breathe, Mrs. B.?

Mrs. B. Not precisely in the same manner that we do; but air is so essential an agent, both chemically and mechanically, in promoting their nourishment and growth, that it is scarcely less necessary to their existence than to that of animals. Indeed, it is the opinion of Professor De Candolle, that the function of transmitting air is

* Trachæ in anatomy means windpipe.

65.—What does Mrs. B. say has long been a disputed point? 66.—What is professor De Candolle's opinion on the subject? 67.—Of what does the sap at first consist? 68.—What is the third system of elementary organs in plants; why do they receive this name; and of what are they composed? 69.—What does Mrs. B. say of air as an essential agent in the production of vegetables? 70.—What does De Candolle suppose in relation to the transmission of air in vegetables?

not confined to the trachæ, but extends to the whole of the vascular system.

The whole of the vegetable kingdom consists of masses of these several elementary organs, with the exception of fungi, mosses, and lichens, whose vessels are all of a cellular form: they have no vascular system whatever.

Emily. That affords a strong argument against the passage of the sap through the vascular system.

Mrs. B. Certainly; the fibres of plants are composed of collections of these vessels and cells closely connected together. The root and stem of plants consist of such fibres: if you attempt to cut them transversely, you meet with considerable resistance, as you must force your way across the tubes, and break them, whilst, if you slit the wood longitudinally, you separate the vessels without breaking them, and have only to force your way through the elongated cellular tissue which connects them.

Emily. The difference is very observable; but I wonder that the cells, being formed of a delicate membrane, are not squeezed and crushed to pieces in the stems of plants, especially when they become hard wood.

Mrs. B. The cells, by the growth of the stem, are frequently drawn out of their original form, and elongated; but the vascular system, which is of the greatest importance, is internal, and lodged in a bed of cellular integument, so that the pressure of the bark or surrounding parts is not sufficient to crush it.

The layers of wood which you may have noticed in the stem or branch of a tree cut transversely, consist of different zones or fibres, each the produce of one year's growth, and separated by a coat of elongated cellular tissue, without which you could not well distinguish them.

The cuticle, which is the external skin or covering of the plant, consists of an expansion of the cellular tissue; and is furnished with pores for evaporation.

71.—With what exception does the whole vegetable system consist of these elementary organs? 72.—How does Mrs. B. prove, that roots and stems consist of the several vessels named? 73.—What difficulty does Emily apprehend to these cells from the growth of the plants? 74.—How does Mrs B. reply to this suggestion of Emily? 75.—Of what is it seen that the layers of Wood consist, when cut transversely? 76.—What is the external covering of the skin called, and of what does it consist?

Caroline. This is, I suppose, neither more nor less than what is commonly called the bark?

Mrs. B. On the contrary it is both *more* and *less* than the bark. *More,* because the cuticle is extended over every part of the plant; it covers the leaves and flowers, with the exception of the pistil and anthers, as well as the stem and branches; *less,* because the bark consists of three distinct coats, of which the cuticle forms only that which is external. The cuticle of a young shoot, after it has been for some time exposed to the atmosphere, becomes opaque, dries, and distended by the lateral growth of the branch, splits, and after a year or two falls off. A second membrane is then formed by the desiccation of the external part of the cellular integument; but it differs from the former in being thicker, and of a closer texture. It is not furnished with pores, having no other function to perform than to enclose a layer of air, and preserve the internal parts from injury. This envelope is distinguished from the former by the name of epidermis.

These general, though, perhaps, rather desultory observations will, I hope, prepare you for our next interview; when I propose to take a full grown plant, examine its structure, and explain the nature of those organs by which it is nourished and preserved. We shall begin with the roots, and then proceed up the stem to the leaves.

Emily. I should have expected that you would have commenced by the birth of the plant, that is to say, the germination of the seed.

Mrs. B. If the plant derives life from the seed, the seed equally owes its origin to the parent plant; and as the preparation of the seed, by that beautiful and delicate system of organs, the flower, is one of the most curious and complicated operations of the vegetable economy, I think it more eligible to reserve it for the latter part of our studies.

77.—Over what parts of the plant does the cuticle extend? **78.**—How is the cuticle described on being exposed to the atmosphere? **79.**—How is the epidermis of bark formed; how does it differ from the cuticle; with what is it furnished; and for the performance of what office is it designed? **80.**—For what is this conversation intended to be preparatory? **81.**—What different course of procedure does Emily say she should have expected? **82.**—What answer does Mrs. B. make her?

Caroline. That is very true so far as regards the formation of the seed; but its bursting, and the sprouting of the young plant, appears to be the natural commencement of the history of vegetation.

Mrs. B. The germination of the seed is a process so intimately connected with its formation and composition, that it is a reciprocal advantage to treat of them together, or, rather, in immediate succession, instead of separating them by the intervention of the whole history of vegetation.

CONVERSATION II.

ON ROOTS.

Mrs. B. We are now to examine the structure of those organs, whose office it is to nourish and preserve the plant.

In the nutrition of plants, six periods are to be distinguished:—

1. The absorption of nourishment by the roots.
2. The transmission of nourishment from the roots to the different parts of the plant.
3. The development of the nourishment.
4. The action of the air on plants.
5. The conversion of nourishment into returning sap or cambium.
6. The secretion of various juices from the sap.

Plants being deprived of locomotion, as we have observed, cannot go in search of food: it is necessary, therefore, that nature should provide it for them in their immediate vicinity. Those simple elements, which are almost every where to be met with, water and air, constitute this food. Water not only forms the principal part of it, but serves, also, as a vehicle to convey what solid food the plant requires; and as a vegetable is unfurnished either with a mouth to masticate, or a stomach to digest, solid food can be received only when dissolved

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83.—How many periods are there in the nutrition of plants? 84.—What are they? 85.—Why is it necessary that nature provide food for plants in their immediate vicinity? 86.—What constitute the food of vegetables? 87.—How can solid food be received by them?

in water. In this state it is absorbed by the roots; for the root not only supports the plant by fixing it in the soil, but affords a channel for the conveyance of nourishment. If it does not fulfil this double office, it is not a root, but a subterraneous branch.

Caroline. But will not a branch, if placed underground, become a root, and absorb nourishment? I have seen the gardener fasten down branches of laurel and other shrubs, leaving only the extremity above ground; and these layers strike root, and become, in the course of time, separate plants.

Mrs. B. Striking root implies, that roots will (under certain circumstances) grow from a branch, but the branch itself cannot be converted into a root; for at the extremity of each fibre of a root, there is an expansion of the cellular integument called a spongiole, from its resemblance to a small sponge, being full of pores, by means of which the roots absorb the water from the soil. Now, a branch, being destitute of this apparatus, cannot supply the plant with nourishment.

Caroline. True: It cannot feed without a mouth; but I thought that there were pores in every part of a plant.

Mrs. B. The pores in those parts of a plant above ground are almost wholly for the purpose of exhalation. The roots have no pores except in the spongioles at their extremities, which, as I have observed, are for the purpose of absorption. It would be very useless for them to be furnished with evaporating pores, since they are not exposed to the atmosphere, where alone evaporation could take place.

Emily. The tendrils of vines, then, and of other climbing plants, which serve to fix them against a wall, or the trunk of a tree, cannot be considered as roots; since, although they answer the purpose of sustaining the plant, they are unable to supply it with nourishment.

Mrs. B. Certainly, these plants are furnished with roots which pump up nourishment from the soil; but there

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88.—How does a subterraneous branch differ from a root? **89.**—What does Caroline say she has seen the gardener do? **90.**—What is to be understood by striking root, in botany? **91.**—What is a spongiole, and from what does it derive its name? **92.**—For what purpose are those pores in plants above ground? **93.**—What are those parts of climbing plants called, which fix them against a wall?

are some parasitical plants,* such as the *Viscum album* or misletoe, and the *Epidendron Vanilla*, which, having no immediate communication with the earth, strike their fibres into the stems or branches of a tree, and derive their nourishment from this richly prepared soil; but as the absorption in this case is not carried on by the regular mode of spongioles, these fibres are not denominated roots.

A root is never green, even when exposed to the light, an element which is essential to the development of the green color in other parts of the plant.

The root, then, by means of the little spongioles attached to its extremities, sucks up whatever liquid comes within its reach; in proportion as it grows, its fibres spread themselves over a greater extent of soil, and come in contact with a greater quantity of moisture; and the plant, whose branches extend above ground, in proportion as the root spreads beneath, requires a more abundant supply of food.

Emily. And do the roots take up every kind of liquid, or have they any means of selecting what is suited for their nourishment?

Caroline. How would it be possible for them to make a choice, having neither reason nor instinct to direct them? For I conclude that the little spongioles are not endowed with the sense of taste, to enable them to discriminate between different sorts of food.

Emily. True; but without endowing the vegetable creation with reason, instinct, or even sensibility, Nature might possibly have so constructed the absorbent pores, that, either by mechanical or chemical means they should reject what was unfit, and receive only what was good for the plant.

* Parasitic, or parasitical plants are those which grow out of another plant, or draw their support from it. The *Lichens* which cover the epidermis of many trees, the *Blight* which destroys the fruit, and the *Beech drops* which are attached to the roots of the tree whose name they bear, are all examples of parasitic plants.

94.—*What are parasitical plants?* 95.—What is said of the *Viscum album* and the *Epidendron Vanilla?* 96.—*What parasitical plants are mentioned in the note?* 97.—What is said of the color of roots? 98.—What produces the color of green in the other parts of the plant? 99.—In what proportion do the branches of plants above ground extend themselves? 100.—What question does Caroline ask concerning the kind of nourishment absorbed by the roots of vegetables? 101.—How does Emily answer her inquiry? 102.—What is the only provision nature has made to regulate this matter?

Mrs. B. The only provision which Nature appears to have made with this view, is, to have formed the pores of the spongioles of such small dimensions, that they are incapable of absorbing a liquid which is thick or glutinous; for if the fluid be loaded with particles not extremely minute, they cannot pass through the tubes which compose the vascular system of the plant. I do not mean to say that these pores have any power to reject a dense or viscous fluid, but that they will be clogged and obstructed by it, and the absorption consequently cease.

Water which has flowed through the manure of a farm-yard, and abounds with nutritive particles, is much used on the Continent, for watering gardens; yet, unless copiously diluted with pure water, it is found to be deleterious, choking the plant with an excess of food. But when the liquid is sufficiently limpid, the spongioles suck it up with equal avidity, whether it contains salubrious nourishment or deadly poison.

Emily. Oh, my poor plants! Why did not Nature grant them some means of preservation from such dangers?

Mrs. B. Nature has bountifully diffused throughout the soil such fluids as are adapted for the nourishment of the vegetable creation. No streams of poison flow within their reach. It is unnecessary, therefore, to guard against a danger which does not exist. It is merely from the experiments of the chemist and the physiologist that we learn that the roots of plants will absorb liquids, of whatever nature, presented to them, provided they be sufficiently limpid. The spongioles act only by capillary attraction, and suck up moisture just as a lump of sugar absorbs the water into which it is dipped. As a proof of this it has been shown, that if roots, saturated with moisture, be transplanted into very dry earth, the latter will absorb the moisture from the roots.

Emily. If so, why do not the roots continue to absorb

103.—What will be the effect, if the fluid which surrounds the spongioles is viscous? 104.—How is it said that manure must be used in order to be serviceable to vegetables? 105.—What fluids has Nature furnished for the vegetable creation? 106.—If Nature furnishes those only which are conducive to the nourishment of vegetables, how is it known that they will absorb others which are not? 107.—On what principle do the spongioles absorb water? 108.—What is the proof that they act on the principle of capillary attraction?

moisture when the plants are dead, as well as when they are living. A sponge, or a lump of sugar, have no vital principle to stimulate them to draw up liquids?

Mrs. B. Neither does absorption immediately cease upon the death of a plant, as the blood ceases to circulate upon the expiration of animal life; but when the vessels through which the fluid should pass have lost their vital energy, that susceptibility of irritation and of contraction, which enabled them to propel the fluid upwards, ceases, and it can no longer ascend into the roots, but remains stagnant in the spongioles, which soon become saturated. Disease and putrefaction follow; and that nourishment, which was designed to sustain life, now serves only to accelerate disorganization. The fluid is, however, still performing the part assigned to it by Nature; for if it be necessary to supply living plants with food, it is also necessary to destroy those which have ceased to live, in order that the earth may not be incumbered with bodies become useless, and that their disorganized particles may contribute to the growth of living plants. Thus the putrefaction of dead leaves, straw, &c. which reduces these bodies to their simple elements, prepares them to become once more component parts of living plants.

Caroline. What a beautiful provision for the vegetable economy! I know not whether you call this botany, Mrs. B.; but it is totally different from the dry classification of flowers. It elevates the heart while it enlightens the mind, and bears more resemblance to lessons of morality and religion than to botany.

Mrs. B. The physiology of plants, of which we are now treating, forms one branch of the science of botany, and one which is certainly replete with interest; but from every natural science, and every branch of it, from the arrangement and classification of the organs of the flower as well as from the history of vegetation, the well-disposed mind will draw lessons of piety; and he must study Nature with very contracted views, who does not raise his

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109.—And, if so, why do not the roots continue to absorb moisture when the plants are dead? 110.—After the plant is dead, in what way is the fluid absorbed by the spongioles, performing the parts assigned it by Nature? 111.—Why is it necessary that disorganization should take place in dead vegetables? 112.—What is mentioned in illustration of this beautiful subserviency in nature? 113.—What effect may such considerations have on the heart?

thoughts from the admiration of the creation to that of its all-wise and beneficent Creator. But to return to our subject.

Botanists distinguish several kinds of roots. The ***Radix fibrosa***, or fibrous root, is the most common and most simple in its form: it consists of a collection or bundle of fibres, connected by a common head, and often merely by the base of the stem. The roots of many grasses and most annual herbs are of this description; during their short existence, which is limited to one summer, they continue growing, both by forming new fibres and by elongating the old ones. These fibres are occasionally covered with a sort of shaggy down, which, as it generally occurs in loose or sandy soil, is considered as a provision of Nature for the purpose of fixing the plant more firmly in the ground.

Emily. Of what description are the roots of those weeds, such as couch-grass, which seem to be interminable. If you attempt to eradicate them, you meet with a succession of bunches of fibres springing from a root which grows horizontally, and appears to be endless.

Mrs. B. This is the *radix repens*, or creeping root. The long horizontal fibre is, in fact, not a root but a subterraneous branch, for it has no spongioles: the real roots are the small bunches of fibres which spring from it. Such a root is very tenacious of life, as any portion in which there is an articulation will grow: it decays at its origin, and continues growing at its extremity.

Emily. Then we must not seek for its origin but its extremity, in order to eradicate it.

Mrs. B. You cannot destroy it without digging up the whole of the subterranean stem: it is this which renders it so difficult to eradicate.

Caroline. Yet surely not more difficult than the Ox-eye and many other weeds, whose strong penetrating roots seem to strike to the very centre of the earth; for, however

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114—What root is most common and most simple in its form, and of what does it consist? 115.—To what vegetables does this root belong? 116.—By what provision of nature are these plants more firmly fixed in the ground? 117.—What description does Emily give of the *radix repens*, or creeping root? 118.—What does Mrs. B. say of the long horizontal fibre? 119.—Where does this root begin to decay? 120.—How can it be destroyed? 121.—What weed is mentioned by Caroline, as being very firmly fixed in the ground?

loosened by digging, they are scarcely ever pulled up entire.

Mrs. B. The root of these plants is called *fusiform*, or spindle-shaped. It is also called the tap root, from its tapering so considerably toward the end; and the pivot-root, owing to its fixing the plant so immovably in the earth. This root is but scantily provided with the means of acquiring food, having sometimes not more than a single fibre furnished with a spongiole at its extremity. To compensate for this disadvantage, the root is of so moist and fleshy a nature as to afford an ample store of provision.

Caroline. But with such limited means of suction, how can this magazine be replenished?

Mrs. B. The surface of the ground immediately exposed to the drying powers of the sun and wind, retains less moisture than the deeper and more sheltered strata of the soil; besides, the store is laid up during the season of abundance, and measured out, as the necessities of the plant require, during that of dearth. Here, you see, are a variety of compensations for its circumscribed power of absorption.

A very simple experiment will convince you, that the spindle-shaped root, as well as those of every other description, absorb water only by the spongioles at their extremities. If you immerse a young radish in a glass of water, so that every part of it shall be covered except the taper end of the root, you will find that it will soon die; while, if you immerse only the extremity of another radish in water, you will preserve it alive. The whole body of the root serves to fix and support the plant in the soil, but it is the extremity alone which absorbs nourishment.*

It sometimes happens that this species of root, whether from want of vigor or some mechanical impediment, is checked in its growth, and wears the appearance of being

* Beets, Carrots, Parsnips, &c. are also of the spindle shaped species.

122.—What is the root of it called? 123.—Why is it also called tap-root, and why pivot-root? 124.—What compensation is made for its having but one fibre more with a spongiole? 125.—What compensation has it besides that of inherent moisture? 126.—What simple experiment is named as showing that the spindle-shaped root, as well as those of every other description, absorb water only by the spongioles at their extremities? 127.—*What roots mentioned in the note are of the spindle-shaped species?* 128.—By what name is the spindle-shaped root called when mutilated?

cut or bitten off. It has hence obtained the name of *radix præmorsa* or abrupt root; but it is, in fact, nothing more than the *radix fusiformis* originally mutilated, and modified by that mutilation in successive generations.

Emily. Is not the Devil's bit Scabious of this description? I recollect hearing a curious story of its acquiring this mutilated form. In the age of sorcery and credulity it was affirmed, that the devil, out of spite to mankind, bit off the end of a plant which was endowed with so many excellent properties.

Mrs. B. The name of the plant is, no doubt, derived from this ridiculous story; but I should be rather inclined to suppose that it was an allegorical compliment to the virtues of the plant, than that such absurdity could obtain belief in any age.

Emily. Bulbous roots, such as those of the hyacinth, the lily, and the onion, are also solitary roots, Mrs. B.; but they seem to fix the plant in the soil rather from their mass than their depth, for they are very superficial; and it is no doubt from the difficulty of finding water, that Nature has added to their root a tuft of small stringy fibres (which are doubtless furnished with spongioles) to multiply the points of absorption.

Mrs. B. The bulbous root, *radix bulbosa*, is improperly so called, for the tufts or fibres pendant from the bulb are alone the roots. The bulb itself, you will learn, when you come to examine its structure, constitutes the stem of the plant; no wonder, therefore, that it is superficial.

Emily. How curious! a globular subterraneous stem?

Mrs. B. If you prefer giving it the name of bud rather than of stem, you may with equal propriety, for it contains the whole embryo plant; but, as we are not at present treating the subject either of stems or of buds, we must reserve this explanation for a more appropriate period.*

* Bulbs are closely allied to Buds. This affinity is less obvious when the bulb occurs in its most usual position, beneath the surface of the

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129.—What is the appearance of the abrupt root, and how is it probably produced? 130.—What curious story, as she calls it, does Emily repeat relating to this root? 131.—What does she say of bulbous roots? 132.—What does Mrs. B. say of the name by which they are called? 133.—What does the bulb contain? 134.—By what other name does she tell Emily it may be called with equal propriety?

Caroline. And are the roots of potatoes of this description?

Mrs. B. The potatoe belongs to the class of knotted or tuberous roots, *radix tuberosa*, which are of various kinds, comprehending all such as have fleshy knobs or tumors. This sort of root belongs to perennial plants, though the knobs are frequently either annual or biennial. In all cases, they are to be considered as reservoirs of nourishment, which enable the plant to support the casual privations of a barren or dry soil.

Some plants, of which Timothy grass is an instance, acquire tumors when situated in a soil subject to vicissitudes of drought and humidity, and lose them if transplated to one regularly supplied with moisture.

Emily. It is wonderful to observe in what an admirable manner roots find means of compensation for local inconveniences!

Mrs. B. The potatoe is a species of mucilaginous, farinaceous excrescence, growing upon subterraneous branches, which have no means of deriving nourishment from the soil; and it is very remarkable, that this salubrious and nutritious substance grows on a plant, the real fruit of which is of a poisonous nature.

The object of nature, throughout all these varying forms, is the same—to establish a reservoir, in which the vital force of the plant and its material resources are husbanded.

The root of the *orchis* is well deserving our notice from its singularity. It consists of two lobes, somewhat similar to the two parts into which a bean is divided.

ground, than when it arises from the bosom of the leaves, or in the vicinity of the flowers. The Bulb-bearing Loose-strife presents an example of the first, and the Meadow-garlic of the second variety; and in both cases it remains attached to the parent plant, till the embryo it discloses has reached maturity. It then falls to the ground, strikes root, and a new plant is developed. In their situation these bulbs are analogous to buds; in their destiny they appear more like bulbs, and are to be regarded as a connecting link between the buds of trees, and the radical bulbs of herbaceous plants.

135.—*What is said of Bulbs in the Note?* 136.—To what class of roots does the potatoe belong? 137.—To what plants does the *radix tuberosa* belong? 138.—Of what are knobs the reservoirs? 139.—What is said of Timothy grass? 140.—How is the potatoe described by Mrs. B.? 141.—What does she say is remarkable in it? 142.—Of what does the root of the *orchis* consist?

One of these perishes every year, and another shoots up on the opposite side of the remaining lobe. The stem rises every spring from between the two lobes, and, since the new lobe does not occupy the same place as its predecessor, the orchis every year moves onwards, though to the distance only of a few lines.

Caroline. Thus, in the course of a certain number of years, the orchis may make the tour of a garden, provided the gardener does not interrupt it in its progress.

Mrs. B. There are some plants which, like the Indian fig-tree, shoot out roots from the stem many feet above ground: they grow downwards, bury themselves in the soil, and new stems ultimately spring up from them; but the epidermis of these roots are never green, like that of young branches.

Emily. I recollect reading an account of a tree which bears some analogy to this fig-tree. It was situated at the top of a high wall, and its roots grew down the side of the wall till they reached the ground, a distance of about ten feet, and then buried themselves in the soil.

Mrs. B. This account is given by lord Kaimes of a plane-tree, situated among the ruins of the New Abbey monastery in Galloway. But the analogy with the fig-tree is only apparent, this singular growth of the roots being merely the result of local inconvenience.

Caroline. I once heard of a curious experiment per formed on a willow-tree. It was dug up, and reversed, the head of the tree was planted in the ground, and the roots, which were now uppermost, stretched out like naked branches in the air. In the course of time, the roots were transformed into branches, and the branches into roots. But how could the latter acquire spongioles?

Mrs. B. They did not; but roots sprouted from the subterranean branches, and branches shot from the unburied roots. This is, however, an adventurous experiment, which does not often succeed.

143.—What description is given of its growth? 144.—What ac count is given of some plants which resemble the Indian fig-tree? 145 —Emily describes a tree which she thinks analogous—what is it? 146. —What does Mrs. B. say of this tree? 147.—Caroline mentions some experiments made with the willow tree—what are they? 148.—What question does she then ask? 149.—What is the reply of Mrs. B.?

The duration of roots is either annual, biennial, or perennial. To the first belong plants whose existence is limited to one summer, such as barley, and a vast number of garden and field flowers. The biennial root produces the first season only herbage, and the following summer flowers and fruit, or seed; after which it perishes. The perennial belong to plants which live to an indefinite period, such as trees and shrubs.

A root consists of a collection of fibres composed of vascular and cellular tissue, but without trachæ or vessels destined for the transmission of air; but there is so great an analogy between the structure of the root and that of the stem, that I shall reserve what observations I have to make on this subject till our next meeting, when I propose to examine the nature of the stem.

CONVERSATION III.

ON STEMS.

Mrs. B. Every plant has a stem.

Caroline. That is to say, trees and shrubs; for there are many plants, such as violets, anemones, fern, and a variety of others, which have large bunches of leaves growing from the roots out of the ground: the flowers, it is true, have each a stem, but the plant itself seems to have none.

Mrs. B. I must repeat my assertion:—every plant has a stem, through which the sap circulates, and from which the leaves and flowers spring. This stem, it is true, is not always apparent: it is sometimes concealed under ground, sometimes disguised under an extraordinary form. The stem of the tulip is contained within the bulb or onion, which is commonly, but improperly. called its root; that of the fern is subterraneous. A very curious plant grows in some of the valleys of the Alps,

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150.—What is the duration of roots? 151.—What are the annual—the biennial—and perennial? 152.—Of what do roots consist? 153.—Through what part of every plant does the sap circulate? 154.—Is the stem always apparent? 155.—Where is it in the tulip; and in the fern? 156.—What curious plant is mentioned by Mrs. B. that grows in the valleys of the Alps?

called willow-grass (*saule en herbe.*) You sometimes meet with a plain covered with it, and you would not imagine whence it derives its origin: it is nothing less than the head, or rather, I should say, the extremities of the branches of a large willow-tree.

Emily. Do you mean a tree which has been accidentally overthrown and buried, the leaves of which have sprouted above ground?

Mrs. B. No; it is a willow which is annually buried alive. Every spring it struggles to rise above ground, and every autumn it disappears beneath the soil. Let us suppose the seed of a willow springing up at the foot of a mountain, and that the earth which is annually carried down by the rains from this mountain should be sufficient to bury the young plant. The following spring it would again shoot out with redoubled vigor; for the growth of the plant having been checked by the fall of the soil, the sap, which should have been expended in the produce of foliage, being accumulated in the little stem, will be sufficient to afford nourishment for a double shoot; two little branches will therefore now appear. This, like its predecessor, flourishes but for a season, and is buried. The two stems the following spring produce four, which expand their leaves, and in the autumn are consigned to the earth; the third year eight stems arise; the fourth, sixteen; and the plant goes on thus doubling its sprouts every year, and the surface of the soil rising, till at length a plain is formed covered with verdure, consisting of the leaves of the willow-tree.

Caroline. What a singular growth! How much I should like to walk on one of these curious meadows!

Mrs. B. They are, as you may suppose, not very common, since it requires peculiar local circumstances to produce one: the vicinity of a mountain which shall annually send down earth sufficient to bury the young shoots, but not so deeply as to prevent their rising from their tomb every spring. The age of these willows has been ascertained by digging down the side of the plain and observing how often the shoots have been renewed;

157.—What is the willow grass? 158.—In what is it supposed to be produced? 159.—Are they numerous? 160.—Why not? 161.—What situation is required to produce them? 162.—What is the appearance if the ground is dug which contains them?

the lower you descend, the more you find the branches increase in size and diminish in number, till at length you reach the original and single stem.

Caroline. But what is the difference between a subterraneous stem and a root?

Mrs. B. The structure of the root and of the stem is in some respects different, and their functions totally so: the former merely sucks up nourishment from the soil and transmits it to the leaves; the latter is supplied with organs to distribute it, variously modified, to the several parts of the plant, the leaves, the flowers, &c.

There is a point or spot separating the stem from the root, called the neck, which may be considered as the seat of vitality. If you cut off the root of a young plant, it will shoot out afresh; if you cut away the stem, it will be renovated; but if you injure this vital spot, the plant will infallibly perish.

Emily. I think it should be called the *heart* rather than the neck of the plant, since it is so essential to its existence.

Caroline. Is not the neck equally so? Animals will not survive decapitation any more than plants. But it is true the situation of the neck does not quite correspond with that of the animal frame, unless you denominate the roots the body of the plant, and the whole that is above ground the head.

Mrs. B. I do not think the huge trunk of a venerable oak would yield that title to its roots, and the extremity of its branches crowned with verdure would lay exclusive claim to the dignity of head.

The stems of plants are divided into two classes: those which grow internally, and those which grow externally. M. De Candolle distinguishes them by the characteristic appellations of *endogenous* and *exogenous*, a distinction first introduced by a celebrated French botanist, M. Desfontanes. We have no corresponding terms

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163.—What is the difference between a subterraneous stem and a root? 164.—Where is the seat of vitality in plants? 165.—What will be the consequence if the root of a young plant is cut off; or if the stem be removed; or if the vital part be injured? 166.—To illustrate the subject, what comparison is made between plants and the animal frame? 167.—Into what two classes are the stems of plants divided? 168.—How are they designated by De Candolle?

in English; in our country these two classes of plants retain the denomination given them by Linnæus, of *monocotyledons* and *dicotyledons*.

Caroline. These are hard sounding names, Mrs. B.: I hope their explanation will render them intelligible.

Mrs. B. I believe you will find no difficulty in understanding them. The class of plants whose stems grow internally, and are by us denominated monocotyledons, are distinguished by their seed, which, during germination, is converted into a thick leaf, yielding nourishment to the young plant until it is strong enough to suck it up from the soil. This leaf is called a cotyledon, and the epithet *mono*, which signifies *one*, implies that this class of plants have a single cotyledon.

The other class, whose stems grow externally, and are called dicotyledons, comprehends all those plants whose seeds in germinating split into two parts, forming two nutritive lobes or seminal leaves; and hence they bear the name of dicotyledons, which signifies two cotyledons.

Emily. I have seen lupins, peas, and beans germinate in this way; but do not recollect having observed any seed germinate with only one cotyledon.

Mrs. B. They are much less common in these climates, at least in plants of sufficiently large dimensions for their cotyledons to be observable.

There is a third class, denominated *acotyledons*, which have no cotyledons and no vascular system, such as fungi, lichens, &c.; but of these we shall not treat at present.

Let us first examine the structure of the stems of the monocotyledons or endogenous plants. Of this description are the date, the palm, and the cocoa-nut tree, the sugar-cane, and most of the trees of tropical climates.

Their stems are cylindrical, being of the same thickness from the top to the bottom; whilst those of Europe, you know, always become more slender and taper towards the summit of the tree, approximating to the conical form.

169.—How by Linnæus? 170.—What explanation is given of the term monocotyledons? 171.—What explanation of the dicotyledons? 172.—What plants are named of the latter class? 173.—What is a third class, and by what name are they called? 174.—What plants and trees are endogenous or monocotyledons? 175.—What is the form of *their* stems?

Caroline. I thought that endogenous plants were those which grew in our own country, in opposition to exotics, or plants of foreign countries; but, by your account, it is just the reverse, for endogenous plants grow in countries most distant from us.

Mrs. B. You confound the word *endogenous* with *indigenous:* the latter signifies to grow within the country; the former is a French word, not yet introduced into the English language, signifying to grow internally, or within itself.

Caroline. Within itself! How can the stem increase in size internally? One would think that the new layers of wood growing in the interior part of the stem would burst the external coats.

Mrs. B. The more the external coats are pressed by the new growing wood, the closer and more compact they become, and the greater the resistance they offer to the internal layers; till at length a period arrives when the outer coats are so hardened and distended as to yield no longer: the stem has then attained its full growth in horizontal dimensions, and offers a broad flat circular surface to view, which has scarcely risen in height above the level of the ground.

Emily. How singular a mode of growing! In this first stage it must resemble the stump of the trunk of a tree which has been cut down; but how does it grow up afterwards?

Mrs. B. The following spring, there being no room for a new layer of wood to extend itself horizontally, it shoots up from the centre of the stem vertically; fresh layers every year successively perforate this central shoot, till from the innermost, it becomes the outermost layer of wood; hard, compact, and of the same horizontal dimensions as the base: the second period of growth is then completed; and thus the stem continues growing, for a certain number of years, horizontally, and then takes a sudden start upwards.

176.—What did Caroline suppose endogenous plants to be? 177.—With what word did she confound the term endogenous? 178.—What is the signification of *indigenous*? 179.—What question does Caroline ask in relation to the meaning of the word endogenous? 180.—How does Mrs. B. describe the internal growth of the stem? 181.—How does she describe its growth after there is room for a new layer of wood to extend isself horizontally?

Emily. The stem then does not begin to rise until it is as large in circumference as at full growth. How I should like to see one of these broad flat stems!

Mrs. B. You may see them growing in hothouses; and though we have none in the open air in these climates, we have many smaller plants of the same description. Corn and all gramineous plants, the liliaceous tribe of flowers and bulbous roots, are all endogenous.

Caroline. But lilies, tulips, and all flowers which spring from bulbous roots have long stems, thick at the lower end, and tapering towards the flower.

Mrs. B. You again confound the stalk of the flower with the general stem of the plant. Both flowers and leaves, with but few exceptions, have each a separate stem or foot-stalk; that of the flower is called by botanists a peduncle or pedicel; that of leaves a petiole. These are perfectly distinct from, and independent of, the general stem of the plant. The stems of bulbous plants are contained within the bulbs as I have already informed you.

Caroline. This mode of growing puts me in mind of the pushing out of an opera glass, the sliding cylinders of which are contained one within the other.

Mrs. B. The leaves and fruit of this class of plants grow from the centre of the last shoot, and form a sort of cabbage at the top of the tree, which, if you cut off, the tree perishes.

Emily. But what becomes of the bark of these trees? How does that resist the pressure of so many successive layers of wood?

Mrs. B. Endogenous plants have no real bark, the external coats of wood are so much hardened as to render such a preservation unnecessary.

Emily. But the palm and cocoa-nut tree, which I have seen at Mr. Loddiges's hothouse, have a very rough external coat, greatly resembling bark.

182.—Where are these broad flat stems to be seen? 183.—What small ones of the same description grow in the open air of our own climate? 184.—What mistake does Caroline make concerning flowers which spring from bulbous roots? 185.—How does Mrs. B. correct this mistake? 186.—Of what does Caroline say this mode of growing reminds her? 187.—What is said of the leaves and fruit of this class of plants? 188.—What is said of endogenous plants as to bark? 189.—What trees has Emily seen of this class which she thinks have bark?

Mrs. B. This is formed of the basis of decayed leaves. A circle of leaves annually sprouts from the rim of the new layer of wood; and, when they fall in autumn, leave these traces of their past existence. When a European wood-cutter begins to fell a tree of this description, he is quite astonished at his hardness. "If I have so much difficulty with the outside," says he, "how shall I ever get through the heart of the wood?" But as he proceeds, he discovers that the trees of the tropical climes have tender hearts, if you will allow me the expression; this circumstance renders it very easy to perforate them, and makes them peculiarly appropriate for masts of vessels, pipes for the conveyance of water, and such like purposes.

These plants have usually no branches; but there is one species of palm-tree which shoots out two or three branches together.

The family of the gramineous plants, that is to say, the grasses and corn have a knot at the base of each leaf, whence the shoot grows.

Caroline. I have observed that the straw of corn is hollow, but closed at certain intervals, forming externally a sort of ring; and it is from these rings that the leaves and branches shoot.

Mrs. B. The sugar-cane, which grows in this manner, is the largest of the gramineous plants.

Lilies are also of this description.

The Yucca of the tropics differs from our liliaceous plants only by having a longer stem; in these temperate climes vegetation has not sufficient vigor to develope all the energies of the plant, and the stem grows only laterally, never shoots upwards, but lies concealed in the bulb. Were it transplanted to a tropical climate, as soon as it had attained its lateral growth, it would shoot upwards in the manner I have described.

190.—How does Mrs. B. say this substance so much resembling bark is formed? 191.—What surprises the woodcutter in felling tropical trees? 192.—Why are these trees good for pipes to convey water? 193.—What is said of their branches? 194.—What is said of the family of gramineous plants? 195.—Which is the largest of gramineous plants? 196.—How does the Yucca of the tropics differ from our liliaceous plants? 197.—What causes this difference?

The structure of *exogenous plants* or *dicotyledons*, to which the trees of our temperate climes belong, is much more complicated. Here, then, are two reasons for our submitting them to a more accurate investigation.

The stem is composed of two separate parts: the one ligneous, the other cortical; in other words, it is formed of wood and bark.

The wood consists in the first place of the pith, a soft medullary substance, which occupies the centre of the stem, and is almost always of a cylindrical form. This soft pulpy body does not grow or increase in size with the tree, but retains the same dimensions it originally had in the young stem.*

Caroline. I thought that it rather diminished; for if you cut a young branch or stem, the growth of one season, the pith is very considerable, while little or none is to be discovered in the trunk of a full grown tree.

Mrs. B. The pith which fills the shoot of one season is scarcely perceptible in a large tree; the quantity, however remains the same. Its dimensions may be contracted by the pressure of the surrounding coats of wood, which sometimes so condenses and hardens it as to prevent its being distinguished from them.

Some trees have a much greater quantity of pith than others; the elder-tree, for instance, abounds with it. The quantity of pith in the branches depends also upon their nature; if the branch is barren, it contains much more than if it is destined to bear fruit, but in the same individual stem or branch the quantity never alters.

* In the ash the pith is uninterrupted and compact, in the Garget ***Phytolacca decandra***, it is composed of transverse partitions intersecting the tube of the stem, which in that plant is unusually large; and in some Thistles, it more resembles the web of a spider attached to the sides of the tube, but neither regularly disposed nor so large as to occupy its entire cavity. In the Hemlock and other Umbelliferous plants it forms a fine delicate lining, remarkable in some cases for its brilliancy, and in many of the grasses it presents a similar appearance. But in the ***Zizania*** or wild Rice, one of the largest grasses in New England, it forms in addition to this lining, distant partitions which interrupt the cavity of the stem.

198.—What is said of the structure of trees in temperate climes? 199.—Of what is their stem composed? 200.—Of what in the first place does the wood consist? 201.—What is said of the growth of the pith? 202.—What does Caroline say of the size of the pith? 203.—How does Mrs. B. account for the pith appearing smaller in large trees than in young branches? 204.—What trees have the greatest? 205.—On what does the quantity of pith depend?

The pith consists of cellular tissue. If this membrane be of a very fine texture, it is susceptible of extension as the branch lengthens; but if it be coarse, and the cells large, when the branch grows, it cracks and separates into parts. This is distinctly visible in a branch of jessamine, if you slit it open so as to exhibit the pith.*

Here is one which we may examine. I will slit it longitudinally: look, Emily, the pith is separated into parts, as if it had been forcibly torn asunder.

Mrs. B. It is the growth of the stem which thus rends the pith in pieces.

Emily. Then is it not destroyed and rendered useless?

Mrs. B. Yes; but not until it has fulfilled the purpose of its destination, which is to nourish the young wood during the first period of its existence.

Emily. It acts the part of a cotyledon or nurse to the young wood. But when it is become dry, what is to perform this office to the new wood which is annually formed?

Mrs. B. Every new layer of wood is lined with a layer of cellular tissue, which may be considered as the pith of the wood to which it is attached. These internal coatings not only separate the several layers of wood, but are also interwoven and incorporated with them, and may be seen in the form of rays, which appear to issue from the central pith, and proceed to the external layer of wood: these are called medullary rays; they are visible in wood, but are remarkably distinct in the root of the carrot.

Caroline. But these fibres or rays, which appear all to proceed from the centre, cannot be continuous, since they originate annually in each fresh growth of wood.

Mrs. B. Very true; but they are so minute and so numerous, that the termination of those of one year's growth, and the commencement of those of the following year, cannot be distinguished. This gives them the

* When young the pith is usually green, becoming of a snowy whiteness when old, though in some few cases it becomes yellow or brown.

206.—Of what does the pith consist? 207.—What is said of the pith of jessamine? 208.—What is the use of pith? 209.—With what is every new layer of wood lined? 210.—What is said of the separation of the layers of wood by these internal coatings? 211.—In what are these coatings remarkably distinct? 212.—Why does Caroline say these rays cannot be continuous? 213.—Why does Mrs. B. say the termination of growth one year cannot be distinguished from the beginning of growth the following year?

appearance of being continuous; but were it really so, their distance from each other would increase in proportion as they diverged from the centre; yet you see in the carrot they are as close, and consequently much more numerous, in the external layers of wood, than in those nearer the central part. In one sense, indeed they may be considered as continuous; as it is conjectured that the growth of the new wood originates from the extremities of the medullary fibres of the preceding year: this would tend to give regularity to the distribution and direction of the successive rays, and an appearance of continuity. A succession of these horizontal rays, perfectly regular, form vertical planes along the stem, which may be tolerably well represented by those circular brushes which are made to clean the inside of bottles.

Emily. The wood of exogenous plants, growing externally, has not the same difficulties to encounter as that of endogenous plants.

Mrs. B. The difficulty is rather reversed than diminished, the pressure being from the external upon the internal parts. The first layer surrounding the central pith grows freely during a twelvemonth, but the following year it is enclosed by a new layer; and notwithstanding the accession of nourishment it receives from the roots, and the additional space it would, if unconfined, occupy, it is pressed and squeezed by the new layer into a narrower compass than it occupied the preceding year. In this distressing situation, what is to be done? Compelled to yield laterally, it makes its way where there is no pressure; that is to say, vertically: thus the stem grows in height at the same time that it increases in thickness. The first layer of wood having, therefore, found a vent for that new portion of its substance which could not be contained in the contracted space in which it was confined by the growth of the second layer, this portion grows freely during the second year; when a third layer shooting up around and compressing the second, this in its

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214.—In what sense may they be considered continuous? 215.—By what may a succession of these horizontal rays be represented? 216.—What does Mrs. B. say of the comparative difficulty of growth in the exogenous and endogenous plants? 217.—How does she describe the growth of the former? 218.—When the first layer is greatly compressed by the growth of the second, how does it make its escape? 219.—What takes place the third year?

turn escapes from bondage, but, rising vertically, it encloses and confines the first layer.

Caroline. The second layer from the prisoner becomes the gaolar; but its prisoner does not excite my commiseration, for the first layer, having learnt how to escape, doubtless profits by its experience, and rises above the fetters with which it is encircled.

Mrs. B. Yes; the first layer thus makes a shoot upwards every year, and the new layers follow its course in regular succession. This mode of growing, you must observe, renders the form of the stem conical, the number of layers diminishing as the stem rises.

These layers of wood attain a state of maturity, when they become so hard by continued pressure as to be no longer susceptible of yielding to it. Previous to this period, the layers bear the name of *alburnum*, signifying white wood, for wood is always white until it reaches this degree of consistence. The length of time requisite to attain a state of maturity varies extremely, according to the nature of the wood. In some trees five years are sufficient for this purpose; in others ten or twenty are necessary; and the Phyllyrea requires no less a term than fifty years to convert its alburnum into perfect wood. When once the first layer has attained this point of maturity, the others naturally follow in succession, according to their respective ages.

Emily. But are those dark-colored woods, such as mahogany and rose-wood, ever white?

Mrs. B. Yes; and what is still more remarkable, ebony, a wood which is completely black, is white until it has attained this state of maturity. Here is a small piece of a branch of ebony cut transversely: you see that the interior parts are perfectly black, and are surrounded by a ring of white wood or alburnum. The difference between the alburnum and perfect wood is less marked

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220.—What comparison does Caroline make to illustrate the relation of the different layers of wood to each other? **221.**—What renders the form of the stem conical? **222.**—When do layers of wood attain a state of maturity? **223.**—By what name are they previously called, and what the propriety of this name? **224.**—What length of time with different trees is required to attain maturity? **225.**—Are dark colored woods ever white; and what ones are? **226.**—What is the appearance of a branch of ebony cut transversely? **227.**—In what woods is the difference between alburnum and perfect more, and in what one is it less marked?

in woods of a lighter color, but it is always sufficiently so to be distinguishable. Look at this trunk of chesnut-tree, which has been recently cut down with a saw.

Caroline. I not only see plainly where the perfect wood is separated from the alburnum, but I can distinguish every layer of wood. I follow them in imagination in their successive shoots upwards to extricate themselves from the pressure of the new layers, by counting the number of layers at the base of the tree; then, Mrs. B., shall I be able to ascertain its age?

Mrs. B. Yes; and you may do more: for if you take the trouble to count the number of layers at each end of one of those pieces of wood which have been sawed into logs for fuel, you will learn how many years that portion of the tree was in growing.

Emily. There are thirty layers at one end, and twenty at the other; consequently the tree must have been ten years growing the length of this log. I little thought I could ever have taken so much interest in a log of fire-wood.

Mrs. B. However mean or common-place may be the purposes to which we apply the works of nature, when studied in a philosophical point of view, they are no less objects of interest and admiration.

The annual layers of wood are distinguishable not only by their different degrees of hardness and density, but also by their being separated by layers of the cellular system; so that, when you examine the trunk of a tree, you perceive zones of woody fibre and zones of the cellular system.

Emily. Can the age of endogenous plants be ascertained in the same manner?

Mrs. B. No; the annual layers of wood are not sufficiently distinct from each other.

Caroline. But the rings annually formed by the vestiges of leaves is a still better record of their age, for it is not necessary to cut down the tree in order to ascertain it.

Mrs. B. For a certain period they may answer this purpose; but these vestiges are obliterated by time, and

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228.—How may it be ascertained how many years a tree has been growing? 229.—What fact does Emily learn from the log of wood, which has twenty layers at one end and thirty at the other? 230.—What moral reflection does Mrs. B. here make? 231.—How are the different layers of wood further distinguishable? 232.—Can the age of endogenous plants be ascertained in the same way? 233.—Why may it not be done by the rings annually formed by the vestiges of leaves?

in an aged tree are no longer distinguishable towards the base of the stem.

Bark.—The vegetation of the bark is precisely the inverse of that of the wood; that is to say, it is *endogenous*, its layers growing internally like those of the palm-tree; the new soft coat of bark therefore lies immediately in contact with the new soft layer of wood.

Emily. But if a fresh layer of bark grows every year, why is the bark so much thinner than the wood? I should have supposed that they would have been of equal dimensions?

Mrs. B. The outer coats of bark, when they become too hard to be further distended by the pressure of the internal layers, crack, and becoming thus exposed to the injury of the weather, fall off in pieces: it is this which produces the ruggedness of the bark of some trees. In others, the rind, though smooth, peels off, after cracking, like that of the cherry, the birch, and particularly the plane-tree. Those trees whose external coat of bark is least liable to peel off, such as the oak and the elm, become more scarred and rugged, in proportion as the tree grows older, and is longer exposed to the action of air, water, insects, and parasitical plants: sooner or later these various causes effect the destruction of the outer bark; and the other layers, as they become external and exposed to the same sources of injury, experience, in due course of time, the same fate; whilst the layers of wood, being protected and sheltered by the bark, vegetate in security.

Caroline. Yet it is not uncommon to see the trunks of very old trees in a state of total decay, whilst the bark remains uninjured.

Mrs. B. That is the case when the wood is, by any accidental circumstances, exposed to the inclemencies of the weather, which it is not calculated to resist. This happens, sometimes, by the lopping or breaking off of large branches, considerable pieces of bark falling off, or any circumstance by which the rain can gain admittance to the wood.

234.—In what manner does bark grow? **235.**—What produces the ruggedness of bark on some trees? **236.**—What takes place in others that are smooth? **237.**—In what proportion do those trees whose bark does not peal off become scarred and rugged? **238.**—Why then does the wood of a tree sometimes decay and the bark remain sound?

There are some trees whose bark is of so elastic and yielding a nature, that it does not harden for a considerable number of years. The bark of the cork-tree, for instance (which is the part commonly called *cork*,) does not begin to harden till after the age of seven years: care is taken to strip it off for the use of the arts before that period. The bark of the plane-tree is, on the contrary, of so hard and inflexible a texture, that it cannot expand, but splits and falls off every season. These two species of trees, the cork and the plane-tree, form the two extremities in the scale of varieties of texture in the nature of bark. The cuticle or external coating of bark is not confined to the stems and branches, but spreads itself over the leaves, and every part of the surface of the plant which is of a green color.

Emily. But the bark of trees is not of a green color, Mrs. B.?

Mrs. B. Recollect that the cuticle is an envelope, which lasts seldom more than a twelvemonth. In those parts of a plant which are of longer duration, such as the stem and branches of trees, the cuticle decays and peels off; and its place is supplied by the epidermis, a coating formed by the desiccation of the external part of the cellular tissue which has been left exposed to the air. The epidermis, therefore, is not green.

Aquatic plants form the only exception, these having, properly speaking, no epidermis.

If you pass a silver wire or *blade* completely through the bark of a tree, the new internal layers, as they are annually formed, will gradually push it outward, till at length the internal coat becoming external, the wire will fall off.

Caroline. That is, no doubt, the cause why inscriptions on the bark of trees are, in the course of time, effaced: the new bark does not grow over them it is true, but growing under them, the inscription becomes distended, and when the bark gives way, it will most readily split and fall off where the inscription has already wounded it.

239.—What is said of the bark of the cork-tree? 240.—What is said of the bark of the plane-tree? 241.—What is said of the cork and plane trees comparatively? 242.—Over what parts of the plant does the cuticle of bark extend? 243.—When the cuticle decays, by what is its place supplied? 244.—How is the epidermis formed? 245.—What is said of aquatic plants? 246.—What experiment illustrative of the manner in which bark grows can be made with a silver wire?

Emily. If, however, the inscription be made so deep as to penetrate the layers of wood, the new layers of bark, instead of injuring, will preserve it.

Caroline. But of what use will be its preservation, whilst it is so buried as to be totally lost to the sight?

Mrs. B. Buried treasures are sometimes brought to light. Adamson relates, that, in visiting Cape Verd in the year 1748, he was struck by the venerable appearance of a tree, 50 feet in circumference. He recollected having read in some old voyages an account of an inscription made in a tree thus situated. No traces of such an inscription remained, but the position of the tree having been accurately described, Adamson was induced to search for it by cutting into the tree, when, to his great satisfaction, he discovered the inscription entire, under no less a covering than three hundred layers of wood.

Caroline. Three hundred years, then, had elapsed since the inscription had been made! How much he must have been gratified by the discovery!—But did not his venerable tree suffer from such deep wounds?

Emily. Probably not: for according to the size of the tree, though he cut so deep, he was still far distant from the centre.

Mrs. B. The centre is not the most dangerous part: on the contrary, the vital part of the stem is situated between the young layers of wood and those of the bark; or perhaps the vitality may be exclusively confined to the inner coat of the bark; for if the young layer of wood be destroyed by frost, the tree suffers but little; whilst, if the inner coat of bark be frozen, the plant infallibly perishes. In the trunk of a tree which has been cut down, it is very easy to trace the effect of frost on any layer that has been injured by it, the wood appearing withered and wrinkled. Mr. De Candolle observed a frostbitten part of this description in a tree cut down in the forest of Fontainbleau in the year 1800; and, by counting the superincumbent layers of wood, he ascertained that it must

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247.—In what way can inscriptions on bark be so made as to be preserved without injury? 248.—What facts are mentioned by Adamson illustrative of the subject? 249.—How long does Caroline infer that this inscription had been made? 250.—Where is the vital part of a stem situated? 251.—How is this shown? 252.—What may be learnt from the trunk of a tree that has been cut down? 253.—What is mentioned by Candolle of a tree in the forests in Fontainbleau.

have happened in the year 1709, which was remarkable for the severity of the frost.

Emily. But since the layers of wood grow with so much regularity, whence come those knots and waving lines, which constitute the beauty of polished wood?

Mrs. B. If the sap, in rising through the young wood, meets with any casual obstruction to its passage, it naturally accumulates in that spot, and forms what is called a knot. This consists of distended vessels, containing a magazine of food, which gives birth to a germ or shoot; but it frequently happens that before this germ has attained strength to force its way through the bark into the open air, a new layer of wood rises over and encloses it. Sometimes it is only temporarily buried; and the following season it acquires sufficient vigor to break through its prison. Thus, if the shoot go on annually forcing its way through the wooden wall which rises up to oppose its progress till it reaches the surface of the stem, it becomes the origin of an external shoot or branch. If, on the contrary, it is exhausted by this series of struggles, it perishes; and leaves, in memorial of its efforts, the knots, waves, and streaks, which embellish its tomb. This shoot which had increased in size whilst traversing the several layers of wood, as soon as it grows externally, diminishes as it protrudes in the air, being thickest at the stem, and tapering towards its extremity; so that a shoot, if traced from its origin, exhibits the form of a double cone, the base of which is at the surface of the stem.

Emily. But whence did this shoot derive its origin? The accumulation of sap can merely favor its growth, but cannot have given it existence.

Mrs. B. This is a question not very easily answered; but the opinion most prevalent among botanists is, that germs or latent shoots exist throughout the stems and branches of plants, and that those only are brought into a state of active vegetation which are fully supplied with food.

Caroline. Do the stems and branches of exogenous plants grow like their roots, merely at their extremities?

254.—What question does Emily ask concerning knots in wood? 255.—What is the consequence if the sap in rising is obstructed? 256—What gives birth to a shoot or branch? 257.—What sometimes will prevent the inward germ from becoming an external branch? 258.—What is its form when it grows externally? 259.—What question does Emily ask concerning the origin of this shoot? 260.—What is the answer of Mrs. B?

Mrs. B. No; they increase throughout their whole length. If you make marks at certain distances on a root, you will find that these distances are not altered by growth; but if you make similar marks on a stem or a branch, the distances will increase, showing that it grows in its whole extent.

Emily. It must be so, since a new layer of wood grows annually at the base.

And pray, through what part of the stem does the sap rise.

Mrs. B. That is a question which has been long and much disputed. Some naturalists have maintained the opinion that it ascended through the pith: others, that it rose through the bark: and they have reciprocally proved each other to be mistaken in their conjectures. A third road was, therefore, sought for; and, by coloring the water with which a plant was watered, it has been traced within the stem, and found to ascend almost wholly in the alburnum or young wood, and particularly in the latest layers.

Caroline. That is very natural. The perfect wood has in a manner finished its active career: it can itself acquire but little nourishment; and its indurated texture would be ill adapted to the conveyance of the sap, whilst the young layers being in the full vigor of growth, and their cellular system flexible and elastic, are much better calculated to transmit it; besides, it is in these, you say, that the young shoots take their origin.

Mrs. B. The sap does not impart nourishment to the plant during its ascent: it is therefore more probable that its rising through the new wood is owing to that being softest and most permeable. By means of the colored medium I have mentioned, it was observed that the sap naturally ascended in straight lines, but that, if it encountered any obstacle, it could move obliquely, or even spread itself laterally.

261.—Do the stems and branches of exogenous plants grow like their roots, merely at their extremities? 262.—What two opinions prevailed with naturalists as to the part of a stem in which the sap ascends? 263. How has it since been ascertained to ascend through the alburnum? 264. —Is nourishment imparted by the sap in its ascent? 265.—How did the sap naturally ascend as it appeared from the experiment with colored water?

A great variety of experiments have been made in order to ascertain the degree of velocity with which the sap rises; but as the rapidity of its ascension depends in a great measure upon the means which the plant has of parting with it by exhalation, we cannot well follow its progress without having previously made acquaintance with the excretory organs of plants—the leaves, whose office it is to exhale that portion of the sap which is superfluous.

Caroline. The whole of the sap then is not required for the nourishment of the plant?

Mrs. B. That nourishment is a more complicated operation than you are aware of: all the water which enters into the plant is not retained by it; part of it passes through the leaves into the atmosphere, and the atmosphere, in its turn, contributes to the nourishment of the plant. But we must not anticipate; and, at our next interview, we will examine the structure and agency of the leaves of plants.

CONVERSATION IV.

ON LEAVES.

Mrs. B. There is nothing more beautiful in the vegetable creation than the gradual formation and development of a leaf. It consists of the flattened expansion of the fibres of the stem from which it shoots, connected together by a layer of cellular tissue called the pabulum, and the whole is covered by a delicate coating of cuticle, which is almost always of a green color. A plant may, indeed, be considered as a continued series of these fibres, sometimes closely bound up in the form of stems, at others spread out into that of leaves.

Caroline. Yet surely, Mrs B., there are many parts of a plant which can neither be referred to leaves nor stems? The blossom, the fruit, and such occasional appendages

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266.—Why cannot it be told with what degree of rapidity the sap rises? **267.**—Is all the water which enters the plant retained for its nourishment? **268.**—What does Mrs. B. say of the gradual formation and development of a leaf? **269.**—Of what does it consist? **270.**—What may a plant be considered! **271.**—What parts of a plant does Caroline suppose c[illegible] not be referred to the stem or leaf?

as thorns and tendrils, cannot come under either of these denominations?

Mrs. B. I beg your pardon: they all originate in leaves. Even the seed, when first ushered into life, comes cradled in a folded leaf; but as in assuming the form of a seed-vessel it loses that of a leaf, we must not allow it to encroach upon the present subject of our conversation, that of leaves properly speaking, which retain their original form throughout the whole of their transitory existence.

Caroline. Well, it must be confessed that this borders on the marvellous; but I shall take it on your authority till the time comes for you to explain it more fully.

Mrs. B. It rests upon much better authority than mine: it is sanctioned not only by the opinion of Mr. De Candolle, but also by the celebrated Mr. Brown, who was the first to develope this theory in England. In Germany, so long as thirty years ago, the venerable poet Goeth wrote a small treatise on the metamorphoses of plants; and if this little work has not met with the attention it deserves, it is probable, that, being written by a poet, it has been considered rather as the effusion of an ardent imagination, than as the deductions of a philosopher. But, whatever be the changes which leaves may undergo, it is our present business to treat of them in their state of leaves.

If, when a leaf shoots, the fibres which attach it to the stem or branch spread out immediately, the leaf is termed *sessile* or continuous; for it cannot be separated from the stem without the fibres being torn asunder; the leaves of corn, grasses, and all gramineous plants, are of this description.

Emily. But it is much more common for leaves to be attached to the branch by a foot-stalk.

Mrs. B. With exogenous plants it is; and the trees and shrubs of our temperate climate are almost all of that class. Such leaves are said to be articulated: the fibres when they first separate from the stem remain bound to-

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272.—Is this opinion correct? 273.—What does Mrs. B. say of the seed? 274.—Who was the first in England to develope the theory to which allusion is made? 275.—What is said of a German work referring to the same subject? 276—When is a leaf called *sessile* or continuous? 277.—What leaves are of this class? 278 —What plants have their leaves attached to the branch by a foot stalk? 299.—How are articulated leaves described?

gether, forming the *petiole* or foot-stalk: thence they expand in numerous ramifications, constituting the ribs of the leaf. Let us now examine this leaf of a horse-chesnut: I cut it transversely at its base, and you may perceive with the naked eye the larger vessels which convey the sap into the leaf. At the other extremity of the foot-stalk they are also visible. They are five in number, corresponding with the five leaflets of which the horse-chesnut leaf is composed.

The fibres of leaves spread out in various directions: the principal one, dividing the leaf from the base to the summit, is called the dorsal, or midrib; others branch out from this laterally; and a third class consists of still smaller ramifications issuing from these last: they all terminate at the surface of the leaf by a pore called *stoma*, a Greek word, signifying mouth.

Caroline. These are, no doubt, the exhaling pores which send off the superfluous moisture.

Mrs. B. Yes; but we must patiently labor through a forest of foliage, before we can return to the physiological operations of the plant.

Leaves are usually divided by botanists into five classes, according to the direction of their ribs:—

First, the pennated are those in which the smaller ribs expand from the principal rib like the feathers of a quill: the leaves of the pear and the lime-tree are of this description.

The second class is palmated. In these, the ribs diverge from the petiole like the fingers from the palm of the hand, as you see in this vine-leaf. They are not, however, always five in number, varying not only in different plants, but sometimes in different leaves of the same individual.

The third class is called target-shaped, or *peltate*, being shaped like a buckler; such is the nasturtium.

The fourth class is *pedatum*, having the form of the foot: the hellebore is of this class.

280.—What illustration is made with the leaf of a horse chesnut? 281.—What is said of the vessels which convey the sap? 282.—What is called the *dorsal?* 283.—What other fibres have leaves and how do they all terminate? 284.—How are leaves usually divided by Botanists? 285.—What is the first class? 286.—What is the second and how is it described? 287.—What is the third class? 288.—And the fourth?

The fifth clsss has simple ribs, proceeding from the base to the extremity of the leaf; corn, grasses, and all the gramineous tribe are comprised within it. These leaves are always sessile.

The contour, or external form of the leaf, is of much less importance than the direction of its ribs. The indentures, or teeth of leaves, are formed by the termination of its ribs.

In the gramineous tribe, the leaves are smooth at the margin, and have no indentures; the ribs run on each side along the margin like a small seam, and terminate at its pointed extremity, whence all the exhalations take place.

When the indentures of some leaves reach so far as half-way down, they are said to be pinnatifid; and when the leaves, though separate, grow from one foot stalk, so that one of them cannot fall off, or be separated from the other without being torn asunder, the leaf is said to be dissected.

Caroline. There are a great variety of leaves of this description: the rose, the acacia—

Mrs. B. No; these are compound leaves, and differ from the dissected by being articulated, each leaflet having a separate foot-stalk, which, when the leaf dies, detaches the leaflet from the general foot-stalk, and they fall separately.

At the base of the foot-stalk of compound leaves there generally grows a small organ, called *stipula:* it consists of two accessary leaves, as you see here in the rose-leaf, the willow, and indeed in most exogenous plants. Sometimes the stipula is attached to the foot-stalk, at others to the stem: it withers easily, and often falls off before the other leaves; for which reason it is not always to be met with on branches of a certain age. In this branch of rose-tree you see that there are stipula to all the younger shoots, while the older ones have already lost them. In the pea the stipula is larger than the common leaves. [See Plate 1.]

289.—How is the fifth one described and what ones does it include? 290.—How are the indentures, or teeth of leaves formed? 291.—In the gramineous tube, how are the leaves described? 292.—When are leaves said to be *pinnatifid,* and when *dissected?* 293.—What is said of the leaves of the rose, and the acacia? 294.—What is the *stipula,* and of what does it consist? 295.—What is further said of the stipula?

When the ribs of leaves are expanded upon the same plane, the leaf is thin; in succulent plants, which retain moisture and evaporate but little, the cellular tissue, which connects the vessels of the upper and lower surface of the leaf, is thick and fleshy.

The two surfaces of a leaf generally differ in appearance: in the upper surface the ribs are the least prominent, and the leaf is consequently the smoothest, and of the deepest green. The under surface is more hairy, and abounds with *stomas* or pores; the upper has fewer, or is sometimes wholly deprived of them, excepting in aquatic plants, whose leaves float on the water; their upper surface being alone exposed to the air, are alone supplied with *stomas*.

But whether the two surfaces be similar or not, it is very certain that their functions are different; for if you reverse the leaf of a plant, and prevent it from resuming its natural position, it will wither and die.

Emily. But corn aud grasses grow vertically, Mrs. B., and can scarcely be said to have an upper and an under surface; though, it is true, they are greener and smoother on one side than on the other.

Mrs. B. All the gramineous family have a more equal distribution of pores on either surface; for growing nearly erect, and being therefore equally exposed to the air, each surface can probably perform the same functions, and these plants can bear the reversion of their leaves better than any other.

Floating aquatic plants, on the contrary, having no pores on their lower surface, infallibly die if they are reversed without power of resuming their natural position.

Caroline. It would be superfluous for aquatic plants to be furnished with pores on their under surface, since they could not evaporate into water.

Mrs. B. Nor can they elaborate the sap without exposing it, by means of the pores, to the atmosphere: but we must complete the anatomical examination of the structure of the leaf, before we enter upon its physiological functions.

296.—What is said of the thickness of leaves? 297.—How do the two sides of the leaf differ? 298.—What will be the consequence if the leaf of a plant be reversed and kept from resuming its natural position? 299.—What is said of the distribution of pores in gramineous plants? 300.—What is said of floating aquatic plants? 301.—And of their elaborating the sap?

The first appearance of leaves which the young plant puts forth on the germination of the seed is formed by the lobes of the seed itself, which we have already noticed under the name of cotyledons.

Emily. I have often observed them in lupins, when they first shoot above ground, and wondered that the tiny plant should be able to supply food to such thick substantial leaves.

Mrs. B. It is, on the contrary, these leaves which yield their substance to the tiny plant; and as soon as they have completed this function, and the whole of their pulpy nutriment is consumed, they wither and fall off.

But all cotyledons are not of a succulent nature: some are thin, like other leaves, and are more commonly called seminal or seed leaves.

Emily. How, then, can they feed the young plant?

Mrs. B. By immediately elaborating the sap, which the nascent root draws up from the soil. Seminal leaves are furnished with stomas for this purpose, while fleshy cotyledons have none; in the latter, the conversion of the cotyledons into leaves is but very imperfect: they frequently remain under ground, and do not assume either the form or color of a leaf.

Emily. The cotyledons of peas and beans are of this description; in those of lupines the conversion is more complete, though they remain succulent.

Caroline. Since the fleshy cotyledons have no stomas, I know not what they have to do in the open air: merely acting the part of a magazine of food, they are more at hand to supply the young plant with it under ground than above it.

Emily. But is it not wonderful that a young plant should be able to absorb sap, and elaborate it from the first moment of its existence?

Mrs. B. Not more so than a young chicken should pick up grains of corn as soon as it has thrown off its egg-shell.

302.—What is the first appearance of leaves? 303.—When do the leaves formed from the lobes of the seed, as in lupins, wither and fall off? 304.—What question does Emily ask respecting seminal or seed leaves? 305.—How does Mrs. B. answer her? 306.—What does Emily say of the cotyledons of peas, beans, and lupins? 307.—What does Caroline say on the same subject? 308.—What question does Emily ask concerning the young plant?

Nature has probably given more firmness and stability to the roots of plants, which are obliged immediately to provide their own food, in the same way as she has to the beaks of young birds. The embryo plant has often another resource, but which does not belong to our present subject.

The first regular leaves which expand are called primordial, and are not unfrequently of a different character from the common leaves of the plant.

When the leaves shoot very near the ground, so as to appear to grow from the roots, they are called radical leaves; they sprout, however, from the base of the stem, for roots never give birth to leaves.

Bracteæ or floral leaves are, on the contrary, leaves peculiar to some plants, which grow very near the flower, and are often mistaken for blossom, not being always of a green color. The Hydrangea, for instance, has a great abundance of pink or lilac bracteæ, which I doubt not but that you have supposed to be the flower of that plant.

Caroline. Are then those beautiful blossoms of the hydrangea not its flowers?

Mrs. B. To a superficial observer they bear, it is true, a much greater resemblance to flowers than to leaves; but, if examined attentively, you will find they possess few of the regular organs of the flower, and could produce neither fruit nor seed.*

Emily. Is there any other example of colored leaves which are bracteæ instead of blossoms?

Mrs. B. A great number. The lime-tree shoots out a profusion of bracteæ of a pale yellow color; and I doubt not but that you have confounded them with the blossom which lies concealed beneath them. The colored leaves

* When this leaf closely invests the flower and assumes the appearance of the calyx, it is somewhat difficult to decide whether it be a bracteæ or not. In such cases if it falls with the other parts of the flower; it is to be regarded as a calyx, but if it remains attached to the fruit till the leaves begin to fade as in the common Fennel flower, it is considered to be a bracteæ?

309.—How does Mrs. B. reply to it? 310.—What are primordial leaves? 311.—What are radical leaves? 312.—What are Bracteæ or floral leaves? 313.—What is said of the Hydrangea? 314.—What is said in the note of bracteæ? 315.—What is said of the bracteæ in the lime tree? 316.—And in the Red-topped Clary?

of the *red topped Clary*, which exhibit various tints of red, purple, and green, are also of this description. There are many bracteæ which do not differ either in color or form from the other leaves of the plant, and are distinguished only by their situation with regard to the flower. Such is the tuft of leaves on the summit of the flower called the crown imperial, and that which grows from the top of the pine-apple: the scaly covering of this fruit consists also of the remnants of degenerated bracteæ.

Caroline. And pray, Mrs. B., is not the scaly cone of the fir-tree of the same nature? I have often observed it when the seeds have fallen out, and it wears the appearance of an aggregation of short, thick, stiff leaves, forming a cone of cells some-what resembling a bee-hive.

Mrs. B. You are quite right; except in calling the fruit which is lodged in these cells seeds: their botanical name is achenium.

Both the fir-cone and the pine-apple are aggregated fruits, separated by bracteæ; but in the succulent pine-apple, almost all vestiges of the intervening bracteæ are obliterated.

Emily. When the crown of the pine-apple is pulled off, the summit of the fruit, I think, exhibits some marks of cells formed by bracteæ.

Mrs. B. That is true; and they are, you may have observed, empty: the pressure of the base of the crown having prevented the fruit from growing, the bracteæ are not wholly obliterated.

Leaves are arranged on the stem in a great variety of ways: sometimes in opposite pairs, and the successive pairs crossing each other at right angles; at others, several leaves shoot from the same spot, and spread out in a circle. They sometimes alternate on the stem, and appear irregularly scattered; but Nature allows nothing to be scattered by chance: upon a careful investigation, order and method will be discerned in the minutest of

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317.—What bracteæ are mentioned which do not differ in color or form from the leaves? 318.—What does Caroline say of the fir-tree? 319.—With what exception does Mrs. B. consider what she says to be correct? 320.—What does Emily say of the pine-apple when the crown is pulled off? 321.—What is the reply of Mrs. B? 322.—What does she ay of the arrangement of the leaves upon the stem? 323.—But what does she say will appear upon careful investigation?

her works; and, in the arrangement of leaves on the stem, she has been studious to prevent their covering each other too closely, both light and air being required to enable them to perform their functions.

Emily. Is it not surprising that Nature should have bestowed so much pains upon so insignificant a part of the creation as a leaf; which, however beautiful and curiously constructed, lasts but a season, and is then scattered by the first blast of wind, and trodden under foot?

Mrs. B. Not until it has performed the part which Nature has assigned to it; and when you are acquainted with the importance of its functions in the vegetable economy, you will probably be induced to treat it with more respect.

Caroline. Leaves, when they first shoot, are generally enclosed in small scaly buds, evidently designed to protect them from inclemency of weather. Now these scales differ totally in form and appearance from the leaves they shelter; and I think, Mrs. B., that you would be at a loss to derive them from the same origin?

Mrs. B. Nothing more simple. All leaves begin to shoot without any external covering; but when, in early spring, they quit the protecting branch in which they were embosomed, to enter into the cold region of the atmosphere, they are chilled and checked in their growth, and, instead of expanding in the natural form, they contract, harden, curve inwards, and are finally transformed into a species of scales, which serve to protect the internal leaves: under so friendly a covering, these vegetate freely. In the mean time the season advances, the atmosphere acquires heat, and the young leaves, having been protected from its former inclemency, are cherished and developed by its genial influence.

Emily. What a beautiful provision for the security of a leaf!

Mrs. B. If you follow up the development of the bud of the ash or the maple, you will observe that the external

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324.—What does Emily consider surprising? **325.**—When does Mrs. B. think she will be induced to treat the subject differently? **326.**—What question does Caroline ask concerning the scaly buds in which leaves are generally enclosed? **327.**—How is this difficulty explained?

scales are short, hard, reddish, and rather hairy. In proportion as they are more internal, they become membranaceous, pale-colored, and elongated; small rudiments of leaves then appear at their extremities; and these, shortly after assume the form of leaflets, so very different in shape and structure from the external scales, that it is difficult to conceive they have had the same origin.

Emily. The more feeble and delicate the leaves of a plant are, the greater, I suppose, will be the number of those which degenerate into scales; therefore, the thicker and warmer will be the covering for the leaves which are ultimately to be developed.

Caroline. And these, being of the same delicate texture, require such an additional clothing. What an admirable effect produced from so simple a cause!

Mrs. B. These scaly leaf-buds are not universal, some leaves being of so hardy a nature as not to require a covering, especially when growing in a warm climate: they are then said to grow naked; but being closely folded or rolled up in a small compass when first they shoot, they wear the appearance of a smooth bud without scales.

The horse-chesnut, in its native climate of India, unfolds its young leaves to the general atmosphere, without risk of their suffering from exposure; while, in this colder country, many successive leaflets are arrested in their growth, and condemned to degenerate into scales. If you examine the buds on this branch, you will see what numbers have changed their form, and are reduced to play a subordinate part in the system of vegetation.

The scales of some buds are formed from the rudiments of stipulæ; others derive their origin from petioles or foot-stalks; which, instead of growing long and slender expand and assume the form of scales, and envelope the embryo shoot. The buds of the waluut and the pear are formed from stipulæ.

328.—Of the buds of the ash and maple what is said? 329.—In what proportion does Emily suppose the leaves of a plant will be converted into scales? 330.—Are these scaly leaf buds universal? 331.—How do those growing in warm climates appear when they first shoot out? 332.—What is said of the leaves of the horse-chesnut? 333.—How are the scales of different buds formed? 334.—Of which class are those of the walnut and the pear?

Emily. I have often examined these buds with great interest, and admired the ingenious manner in which the leaves were so closely packed, in order to be contained within them. Do the same buds produce both leaves and flowers?

Mrs. B. Buds vary in this respect not only in different plants, but sometimes even in the same individual: some sprouting into flowers and fruits; others into leaves only, and branches; and there are buds of a third description, which develope both fruit and leaves. The first kind is full and round; the second, smaller and more pointed; and the third, both in size and shape, forms a medium between the other two.

Caroline. How essential it must be for a gardener to be able to distinguish these buds! For if, in pruning a tree, he were to lop the branches which contained most of the fruit-buds, and retain those which had more leaf-buds, he would have a very poor crop of fruit. Are these three species of buds common to all trees?

Mrs. B. No; the buds of the horse-chesnut, which are so large, scaly, and glutinous, are all of the mixed kind; those of the apple and pear are of the two distinct species.

Endogenous plants, or monocotyledons, scarcely ever produce more than one single bud annually; the cabbage of the palm-tree is its bud, and the leaves and flowers are folded within it. The cocoa-nut and date trees develope their flowers and foliage in the same manner.

Bulbous plants (the endogenous plants of our temperate climate) are of the same description. I have already observed, that their stem is contained within the bulb; but you have yet to learn that this bulb is in fact the bud or cabbage, containing not only the stem, but also the leaves and flowers. The scales formed for the rudiments of undevoloped leaves are particularly distinct in bulbous roots, especially in the onion.

Emily. Thus then a lily, a tulip, or a hyacinth, are all contained within their bulbs, which we have been accustomed to consider merely as their root. But these

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335.—Three kinds of buds are named—What are they? 336.—Are they common to all trees? 337.—What is said of the palm-tree, the cocoa-nut, and the date-tree? 338.—What is contained in the bulbous roots? 339.—What is said of the onion?

flowers have each a stem, Mrs. B., independently of that which you say remains undeveloped within the bulb.

Mrs. B. The shoot which you consider as a stem, is the peduncle or foot-stalk of the flower, not the stem of the plant; the leaves which grow from the stem shoot from beneath the footstalk. The bud or cabbage of the palm tree, when developed, shoots up a footstalk on which the flower expands, while the leaves spread out at its base. The difference between these plants of the tropical and of the temperate zones is, that the stem of the palm-tree being developed, the cabbage is situated at its summit; whilst, in our more temperate climate, the vegetation of the bulbous plants is not sufficiently vigorous fully to develope their organs, and the stem remains in a latent state within the bulb.

Caroline. How can those plants bud whose stem and branches die annually, such as dahlias, paeonies, and China asters, &c.?

Mrs. B. The new stem and branches shoot from a bud formed at that vital spot called the neck of the plant; in perennials the stem dies down to this spot, but if that perishes, the whole plant dies. It is situated either on a level with, or rather below, the ground; and the bud being but little exposed to the weather, is not provided with the same warm covering as most of those which sprout in the air.

Caroline. That is to say, being protected by their situation, the first rudiments of their leaves do not degenerate into scales.

And pray, do all these various kinds of buds originate in some little accumulation of sap in the stem, in the manner you have described to us?

Mrs. B. This accumulation of sap is the origin of a bud, so far only as it enables a germ or embryo shoot to grow, by affording it an ample supply of food.

340.—What is the error of Emily concerning the bulb? **341.**—What is said of the bud of the palm-tree? **342.**—What difference is there between these plants of the tropical and the temperate zones? **343.**—How can those plants bud whose stem and branches die annually? **344.**—How far is an accumulation of sap the origin of a bud?

They commonly shoot at the articulation of a leaf, because the branching off of the vessels offers some little impediment to the flowing of the sap; a small portion of it is arrested in its course, and forms a deposition of food, which a neighboring germ quickly applies to its own use, and is thus ushered into life.

Emily. Such germs must exist then in a latent state in every part of the stem, and wait only for means of sustenance to make their appearance externally.

Mrs. B. In all probability; for wherever there is an accumulation of sap, a germ is sure to be developed.

Emily. When I plant a slip of geranium, I take care that it should have at least one leaf; because I know by experience, though I was quite ignorant of the cause, that the shoot would spring from the articulation of the leaf.

Mrs. B. In geraniums there is also another species of articulation, consisting of knots in the stem, which answers the same purpose, by interrupting in some measure the circulation of the juices, and affording a little supply of stagnant sap. Pinks and carnations, reeds and rushes, the stems of corn and grass, are all intersected in a similar manner.

Caroline. Then when carnations and pinks are propagated by layers, the shoots take place at those intersections of the stem.

Emily. Excepting the geranium, the leaves of all these plants are, I believe, sessile; the intersections in the stems, must therefore supply the place of articulations in furnishing the buds with food.

Mrs. B. Precisely so. They belong to the class of endogenous plants, whose leaves are more rarely articulated than those which are exogenous. These intersections, however, not unfrequently occur in the latter, as with the geranium, the vine, and several other dicotyledons.

345.—Why do they shoot at the articulation of a leaf? 346.—What is said by Emily of such germs existing in a latent state? 347.—When planting a slip of geranium why has she been careful to have at least one leaf? 348.—In what besides geraniums is there another species of articulation, consisting of knots in the stem? 349.—Of what description are the leaves of all these plants, excepting the geranium? 350.—To what class of plants do they belong?

You may reccollect my observing, that a number of years frequently elapsed before the buds formed on the stem or branches of a tree attained sufficient strength to force their way through the successive layers of new bark which annually enclosed them; while others vigorously pushed through this barrier the first year. Buds usually begin to be formed in the month of August, and remain in a latent state during the winter, when they are commonly called *eyes:* the following spring they shoot; but they cannot properly be called buds till the scales are formed by the degeneration of the external leaves of the shoot.

It is heat which determines the period of budding of a plant. A branch turned towards the south, or introduced into a greenhouse, will shoot long before the rest of the tree; the budding begins to appear first near the extremity of the branches where the wood is most soft and tender.

Emily. I should have imagined that the base of the branch which the sap first reaches would have budded earliest.

Mrs. B. In the larch, and many other trees whose branches are equally hard throughout, this is the case; but the superior facility of piercing through the tender part of a branch more than compensates for the earlier supply of food.

The scales of buds are often coated with a sort of glutinous varnish, which resists moisture; some are lined with a species of down or fur, to preserve the internal shoot from cold.

Caroline. But can down or fur result from the degeneration of leaves? Such a beneficent provision for the protection of the shoot would seem to indicate, that the bud of a distinct organ is specifically designed for that purpose.

Mrs. B. Such is no doubt equally its destination, whether it originate in the abortion of another organ, or whether expressly created for that purpose: nor is it diffi-

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351.—What has before been said of bulbs remaining in a latent state? 352.—When do buds usually begin to form; how long do they remain in embryo state; what are they then called; and when do they shoot forth? 353.—What determines the period of the budding of a plant? 354.—What proves this? 355.—In what part of the branch—near the base or the extremity does budding first take place? 356.—With what are scales of buds sometimes coated and with what are some lined?

cult to refer the formation of down or varnish to the same origin. The scales of buds probably absorb from the sap only a portion of what was destined to nourish them had they been developed into leaves, and the remainder may be converted into a species of glutinous resin or varnish. The rudiments of leaves, when examined in the bud before it is developed, wear the appearance of small filaments of cotton, which, when spread out, exhibit the minute skeleton of a leaf.

It would be difficult to suggest a mode of folding or rolling which Nature has not adopted in enclosing these embryo leaves in the bud. They are sometimes, as those of the vine, folded like a fan; others are double from the top to the bottom; others folded down the middle; some are laid one within another; others closely packed side by side; and there are an equal number of modes of rolling them up in the buds.

In some plants the petioles or foot-stalks retain the nourishment they should transmit to the leaves, so as to prevent the latter from being fully developed; they remain therefore in an embryo state; the petiole, in the mean time, gorged with nutriment, becomes thick, corpulent, and clumsy, flattening as it expands, and wears rather the appearance of a leaf than of a stalk. The acacia of New Holland has this singular conformation.

Caroline. I have seen tropical plants in hothouses of this description: the prickly fig is, I believe, one of them. But how do these leafless plants disburden themselves of the superfluous moisture which leaves exhale?

Mrs. B. The dilated petioles, which usurp the place of leaves, perform also, though but imperfectly, their functions, and have pores adapted for that purpose: they are not, however, leaves, any more than the tail of a kangaroo is a leg, or the trunk of the elephant an arm, though they respectively perform the office of these members. When common organs assume in certain species an un-

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357.—What becomes of the sap in the branches not needed for the nourishment of the scales of the bud? 358.—What is said of the rudiments of the leaves when examined in the bud before it is developed? 359.—What are the different ways in which embryo leaves are folded? 360.—What is said of the petioles which retain the sap, which they should transmit to the leaves? 361.—What is an instance of this? 362.—What is said of dilated petioles which usurp the place of leaves?

common form, they may be useful for purposes different from those for which Nature originally designed them; but they should not on that account obtain the name of the organ they but imperfectly imitate.

Leaves are usually deciduous, that is to say, last but one season; there are but few exceptions of plants whose leaves last two, three, and sometimes as long as four years. Evergreens change their leaves annually, and the plant remains green only because the young leaves appear before the old ones decay.*

Emily. Is it not singular that the leaves of evergreens should wither and fall in the spring, when the weather becomes warm, the sap most abundant, and vegetation in full vigor?

Mrs. B. A leaf withers when the vessels which should bring it nourishment are no longer capable of performing that function. In autumn, the vessels of the petiole become obstructed by a deposition of hard matter, which disables them from transmitting sap, and, being no longer moistened by the passage of this fluid, they dry up and wither; while the pabulum of the leaf, consisting of an expansion of the cellular system, which is of a soft, moist nature, preserves the leaf some little time after the petiole has ceased to perform its functions.

Caroline. Like an animal deprived of sustenance, it feeds on its own fat, before it perishes.

Mrs. B. The circulation of sap in evergreens being more uniform throughout the year, the deposition of hard

* The trees of equinoctial regions are perpetually verdant, and the same leaves which have been noticed as unusually large, are equally remarkable on account of their longevity, as they rarely fade till they are six years old; yet these very trees, when removed to a colder region, are in some cases annually stripped of their foliage. In its native country the far famed Cydon, and also when cultivated in the south of Europe the Quince tree is evergreen, though here, as we have abundant opportunity to see, it annually parts with its leaves. On the other hand the Currant, which was originally an inhabitant of the northern countries of Europe, when transferred to the Island of St. Helena was soon crowned with perennial leaves, but it there produces less fruit than in its native country.

363.—When common organs assume an uncommon form, what is said of them? **364.**—How long do leaves last? **365.**—What is said of evergreens? **366.**—*What is said of leaves in equinoctial regions; and when removed to colder regions?* **367.**—*Of the Cydon and Quince what is said?* **368.**—*What is said of the currant?* **359.**—When does a leaf wither? **370.**—Why does not the leaf die immediately on the petiole's ceasing to perform its functions?

matter does not obstruct the passage of the sap till towards the spring, when the vigorous sap is directed towards the buds, and the old leaves drop off as the young ones expand.

The petioles of some leaves, such as the aspen and the poplar, are flattened, and adhere less firmly to the stem; hence they tremble at every breath of wind, and fall off more readily than those of a cylindrical form.*

With regard to the most important functions of the leaves, the chemical changes they operate upon the sap, we must reserve them for our next interview, which I propose to dedicate to the examination of the sap, and the interesting part it performs in the vegetable system.

CONVERSATION V.

ON SAP.

Mrs. B. Now that you have made acquaintance with the *root*, the *stem*, and the *leaves*, we may proceed to trace the sap in its ascent through these several organs, observe the various transformations it undergoes in the leaves, and, following it in its descent, examine the manner in which it feeds and restores the several parts of the plant.

* The magnitude of leaves varies almost as much as their forms. In the mosses which abound in cold climates, they are extremely minute; and the forest trees of the North are adorned with leaves which appear diminutive, when compared or rather when contrasted with the foliage of Equatorial plants. There we find the leaves of the Banana, perhaps the same which were employed by our first parents, to supply the want of a more artificial dress; they being in the opinion of many writers the "Fig leaves" of sacred history. In Ceylon, a country alternately exposed, for many months in succession, to the rays of a vertical sun, and the inclemencies of an unceasing storm, is found the singular Talipot, a single leaf of which is sufficiently large to shelter twenty men from the vicissitudes of the climate in which they dwell. This tree is venerated by those who find beneath its branches so kind a shelter, and travellers consider it, as the greatest blessing which Heaven has bestowed on the country. And when we regard its subserviency to the wants of the human race, it is not surprising that by the ancients, the wide spreading tree, decorated with leaves and occasionally beautified with flowers, should have been held sacred as the very temple of the Deities they worshipped.

371.—Why do not the leaves of evergreens wither till spring? 372.—What is said of the leaves of the aspen and the poplar? 374.—*What is said of the leaves of the Banana? 375.—And of the leaves of the Talipot?* 376.—What is to be the subject of the fifth Conversation?

Caroline. This seems to me to comprise the whole history of vegetation.

Mrs. B. In a general point of view it does, but we shall yet have many details to enter into; besides, what I have hitherto said relates only to the nourishment of plants: their re-production is of no less importance, and we have not yet ever alluded to the flower, the most distinguished and beautiful of their organs, and that in which the seed originates.

Emily. But this sap, Mrs. B., which I imagined to be diffused through the plant as it rose, seems to be disposed of in a very different manner: part you say is exhaled by the leaves; and part descends through the bark; what then remains to nourish the plant?

Mrs. B. All that is necessary for that purpose is selected and retained. If you consider that the sap which rises in the roots consists simply of water, holding in solution a variety of crude ingredients, such as lime, silex, magnesia, soda, and potash, you will acknowledge that something more is required than the mere diffusion of this heterogeneous fluid through the plant in order to nourish it. The sap traverses the stem, rising, as I have already said, through the alburnum, and some small portion of it through the perfect wood. A great variety of experiments have been made, with a view of ascertaining the degree of rapidity with which the sap ascends. M. Bonnet raised some plants in a dark cellar, in order to blanch their stems, that he might be able to trace the ascent of the colored water with which he nourished them. He found that this tinted sap rose only four inches in two hours; but the plants, owing to the disadvantageous circumstances under which they were cultivated, were weak and sickly; in subsequent experiments on more healthy plants, the sap was seen to ascend three inches in the course of an hour. Some time afterwards Mr. Hales immersed a fresh cut branch of a vigorous pear-tree in a tube full of water, and found that the sap rose in it eight inches in six minutes.

377.—What is here said of the re-production and flowers of plants? 378.—What crude ingredients must the sap be considered as holding in solution? 379.—What experiments were made by Bonnet? 380.—What ones were made by Mr. Hales?

Emily. And how do you account for so remarkable a difference in the result of these experiments?

Mrs. B. Chiefly from the improved mode of performing them. The velocity of the sap varies, however, very considerably, owing to a variety of causes: the nature of the plant, the degree of temperature, and, above all, the quantity of solar light; which last is absolutely required to enable the leaves to evaporate the superfluous water.

During the spring there is a more than usual absorption of sap, for the purpose of nourishing the young buds which are to be developed; and it is very worthy of remark, that the sap which feeds these buds passes through different channels from that which serves to nourish the plant generally. Instead of rising through the young wood, it ascends nearly in the centre of the stem, in the parts contiguous to the medullary channel, and is thence transmitted, by what means is not yet ascertained, through the several layers of wood to the buds.

Emily. But the sap that nourishes the buds which first shoot in the spring, cannot have been passed through the leaves, and undergone that change which you say is necessary to convert it into appropriate food. Can it feed the buds in the crude state in which it rises in the stem?

Mrs. B. There is great reason to suppose that it is in some measure elaborated during its passage from the roots to the buds; probably by the organs which it traverses in passing laterally from the centre to the circumference of the stem or branch; but it is a point very difficult to ascertain, owing to the extreme minuteness of these organs: it is, however, a very reasonable inference, since the sap, when it reaches the buds, is in a state ready to be assimilated to their substance.

Part of the sap, which rises in the month of August, in all probability follows the same course, being destined to nourish the new buds which shoot at that season; but it is less abundant than that of March, having fewer buds to bring forth.

381.—How is the remarkable difference in the result of these experiments accounted for? 382.—What is said of the quantity of sap absorbed in the spring? 383.—In what part of the stem does it ascend? 384.—Emily asks if sap can feed the buds in the crude state in which it rises in the stem—what is the answer of Mrs. B.? 385.—What is said of the sap which rises in August? 386.—Why is it less abundant than in March?

Emily. How much this sap, destined for the nourishment of the young buds, resembles the milk of animals, a provision which Nature has made for a similar purpose, and which is secreted from the common stock of nourishment only when there are young to feed on it.

And pray what is the cause that produces the rising of the sap in spring?

Mrs. B. Heat is the circumstance most favorable to the absorption of this *nursling* sap, as it is heat which first expands the buds, and makes room for it. An experiment has been made by placing two pieces of vine in two similar vases of water, and then introducing the stem and branches of one of them, through a hole in the wall, into a hothouse: the buds of this plant were rapidly developed, and the water in the vase as rapidly absorbed; whilst the buds of the other plant made only the usual progress, and the water in the vase diminished in the same slow proportion.

If plants are pruned in the spring, the sap will rush out often with violence: in vineyards, this flowing of the sap, when plants are cut, is called the tears of the vine. Mr. Hales made an experiment by cutting off the upper end of the branch of a vine, and enclosing the wounded extremity of the lower part (which remained on the stem) in a tube; the sap flowed from it with such violence, and in such abundance, as to rise to the height of forty-three feet in the tube, thus sustaining the weight of one atmosphere and a half.

Caroline. What a prodigious force! Of course, if you make an incision into the stem of a tree in the spring, the sap will flow out.

Mrs. B. No, not at least with violence, for the spring sap rises with force, only in shoots of one year's growth, and will consequently flow with velocity from none but these. In making the incision, you must penetrate to the centre in order to reach the full channel of the spring sap,

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387.—To what does Emily compare sap? 388.—What causes sap to rise in the Spring? 389.—In what experiment was it made manifest that heat was a principal agent? 390.—If plants are pruned in the spring what is said of the sap? 391.—The tears of plants, are what? 392.—What experiment was made by Mr. Hales, and what was the result? 393.—Why will not the spring sap flow out with violence if an incision be made in the tree?

and the instant your instrument reaches the pith, you will hear the sap gush, and see it follow the instrument as you draw it out.

We must not, however, bestow the whole of our attention on this nursling sap, but return to that which rises through the alburnum to feed the mature plant. This sap reaches the leaves without having undergone any change; but as soon as it arrives there, a considerable portion of its water exhales by the *stomas*, leaving the nutritive particles which it held in solution deposited in the leaf.

Emily. And pray, what is the proportion of the quantity of water evaporated to the whole quantity absorbed by the roots!

Mrs. B. It varies exceedingly, according as circumstances are more or less favorable to evaporation. A plant can evaporate only in proportion to its absorption: the quantity, therefore, depends not only on the abundance or deficiency supplied from the soil, but also on the number of ramifications of the roots; that is to say, of mouths to suck up water. On the other hand, these mouths, however numerous and abundantly supplied, can continue to receive water only in proportion as the exhalation by the leaves carries off what has already been taken in, so as to make room for more. Thus while water enters at one extremity of the plant, it must find its way out at the other.

Emily. Were you to poor water into a tube closed at the opposite end, it would soon be filled, and, though you continue to pour, it would receive no more, and the water would flow over; but if you opened the closed end, you might pour in at one end as fast as it flowed out at the other. But what is it that promotes the flowing out, or, in other words, the evaporation, of the water by the leaves?

Mrs. B. The most essential circumstance is *light.*

Caroline. You surprise me: I should have thought that heat would have been more necessary than light to produce evaporation.

394.—What will take place if the instrument with which the incision is made reaches the centre? 395.—What takes place with the sap, that rises through the alburnum, on reaching the leaves? 396.—On what does the quantity of water evaporated depend? 397.—On the other hand what is said in relation to this subject? 398.—What illustration does Emily give of the tube filled with water? 399.—What causes the evaporation of water by the leaves?

Mrs. B. Heat augments it mechanically: but without light no exhalation from the leaves will take place; and it will even be inconsiderable, unless the sun's rays fall upon the plant.

Caroline. Is it not very singular that light should be most favorable to the ascension of the sap which passes through the alburnum, whilst heat is most congenial to that which rises through the centre of the stem? What is the reason of this difference? For both saps, I conclude, must be of the same nature, since the spongioles cannot choose, but must suck up whatever is sufficiently fluid to enter their pores?

Mrs. B. Being derived from the same source, they were, no doubt, originally of the same nature; but when separated into different channels a difference arises: the nursling sap, we have concluded, undergoes a preparation in its passage towards the buds, and their expansion, produced by *heat,* is alone required to call it up.

While the sap which passes through the alburnum must not only throw off a considerable quantity of its water by the leaves, but also undergo a chemical change, for both of which processes you will find that the aid of the solar rays is absolutely required.

Let us first consider the simple evaporation by the leaves. The quantity of water exhaled by plants, is to that which they absorb generally in the proportion of two to three; one third only, therefore, remains in the plant, and becomes a part of its substance; the rest may be considered simply as a vehicle which Nature had employed to convey a due quantity of nourishment into the plant, and which, after having deposited its cargo, disappears.

Emily. Is the water then which is evaporated perfectly pure?

Mrs. B. It does not contain above a ten-millionth part of the foreign matter which it held in solution when absorbed,—a very trifling per centage for the expense of freight.

400.—What explanation does Mrs. B. give of the agency of light and heat in this work? 401.—What question is asked by Caroline as to a singular phenomenon in the ascension of sap? 402.—What does Mrs. B. in reply say of the nursling sap? 403.—What does she say of the sap which rises through the alburnum? 404.—The quantity of water exhaled by plants is in what proportion to that absorbed? 405.—Is the water thus evaporated pure?

This exhalation is not visible, because the water is so minutely divided as to be dissolved by the atmosphere as soon as it comes in contact with it.

Caroline. It may then be compared to our insensible perspiration.

Mrs. B. True; and it is called by many botanists the perspiration of plants, and it sometimes happens (as is the case also with animal perspiration) that it becomes sensible. This occurs only in plants whose leaves have simple ribs uniting at a point at the extremity of the leaf. The sap is accumulated by the absorption of the roots during the night, and that portion of it which is destined to be evaporated flows towards this sole aperture, and may be seen there in the form of a minute drop, if observed before sunrise, for it is reduced to vapor by the first solar rays: the subsequent evaporation being equal to the absorption, no accumulation takes place, and no fluid is perceptible. This effect may be seen on the leaves of corn, which, with all the gramineous family, have simple ribs.

Caroline. Plants, then, must increase in weight during the night, since they absorb by the roots without exhaling by the stomas?

Mrs. B. They do so; and whenever, through any accidental cause, the stomas are obstructed or diseased, the plant becomes dropsical, from the accumulation of the water it has taken in and cannot discharge. Plants growing in vases in a room are very subject to this malady, owing to their not having sufficient light to evaporate freely.

Emily. Yet if you expose a nosegay in a room to the sun's rays, it withers.

Mrs. B. Because the sun produces a degree of evaporation which the poor mutilated flowers are unable to support; for though the stalks may be immersed in water, the organs of absorption are wanting, and the quantity of water they suck up is quite inadequate to the evaporation

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406.—Why is not this exhalation visible? 407.—What is it called by botanists? 408.—With what plants does perspiration become visible? 409.—When and in what form may it be seen? 410.—Why do plants increase in weight in the night? 411.—When do they become dropsical? 412.—What plants are subject to this malady? 413.—Why do flowers separated from their roots wither in the sun's rays?

Since, therefore, you have deprived them of the power of absorption, you must diminish, at least, that of exhalation, and, by keeping them in some degree of obscurity, endeavor to preserve the sap which they already contain.

Emily. I should be curious to know what quantity of water a plant exhales in a day.

Mrs. B. It has been ascertained by Mr. Hales, that a full-blown helianthus, or sunflower, placed under advantageous circumstances in regard to light and temperature, evaporated twenty ounces of water per day, which is seventeen times more than that evaporated by a man, supposing their surfaces equal. This experiment was made by weighing, first, the water in the vase in which the sunflower was placed, then the plant itself; and, after due time being given to the experiment, the water and the plant were again weighed. The plant had absorbed as much water as the vase had lost; but it was not found to have increased in weight so much as the water in the vase had diminished by twenty ounces, which affords a conclusive proof that these twenty ounces had been evaporated. Of course, suitable precautions had been taken in order to prevent any immediate evaporation from the water contained in the vase. Fleshy fruits, such as apples, plums, peaches, &c. have few or no pores: they therefore retain the moisture they receive from the sap, which enables them to remain long on the tree, after coming to a state of maturity, without drying up and withering. Whilst dry fruits, such as peas o beans, wither in consequence of the number of their pores by which they exhale moisture. There is the same difference between thick fleshy leaves, such as those of the cactus and other succulent plants, and dry leaves, such as those of the pine and the fir, which are at the opposite extremity of the scale; common leaves bear a medium, between the two, but, in the same space in which a common leaf contains six or seven stomas, the leaf of a pine has sixty or seventy.

414.—Why may they be preserved longer in the shade? 415.—How much water was a full-blown helianthus, or sunflower known to evaporate in a day? 416.—How was the experiment made? 417.—Why do apples, plums, peaches and other fleshy fruits remain a long time on the tree without withering, after having come to maturity? 418.—And why do peas, beans &c. dry so soon? 419.—What is said of the dying of leaves?

Emily. Aquatic plants which live wholly under water, you told us, were not provided with stomas; but now that I comprehend the nature of their functions, I do not understand why the plants should not derive benefit from them: for while the roots absorbed the water holding ingredients in solution, the stomas would evaporate it in a pure state, leaving all its riches behind.

Mrs. B. The plant has not power to exhale water into water: it requires the assistance of the air to dissolve it and carry it off. Those aquatic plants which rise to the surface, are abundantly furnished with stomas to disburden themselves of their excessive supply of water.

Let us now turn our attention to the nature of the sap which remains in the leaf, after having disengaged its superfluous moisture. It consists of about one-third of the water originally absorbed by the roots, but augmented and enriched by the acquisition of all the nutritive particles which the evaporated water has deposited.

Caroline. In this state it is certainly better calculated to nourish the plant; and from this ample store I suppose the various organs select and assimilate the food they each require.

Mrs. B. It is true that every organ performs a chemical change on that part of the sap which it assimilates to its own substance; but the sap previously undergoes a general change, in some measure analogous to that which the blood undergoes in the lungs, to prepare it for assimilation. This operation is also performed in the leaves, which may be considered as the laboratory in which the sap is submitted to a regular chemical process.

Emily. This, indeed, bears a very striking resemblance to the chyle, which is the sap of animals, and which is converted into blood, fitted to go through the general circulation, and nourish the several parts of the body.*

* See Conversations on Chemistry Conversation xxv.

420.—What does Mrs. B. say of aquatic plants as to their power of exhaling water? 421.—And what does she say of the sap which remains in the leaf after perspiration has taken place? 422.—What change does the sap undergo previous to its becoming assimilated to the several parts of the plant? 423.—Where is the operation performed? 424.—To what does Emily say this process of the sap bears a strong resemblance.

Mrs. B. The analogy is perhaps even stronger than you imagine; for this process, which in animals is performed by means of breathing atmospherical air, in vegetables is performed by the same air acting on the sap when it comes in contact with it at the stomas: the leaves may therefore be considered as the lungs or organs of respiration of plants.

Emily. How curious! their stomas then are so many little breathing mouths. And does the oxygen of the atmospherical air carry off carbon from the sap, as it does from the chyle?

Mrs. B. On the contrary, carbon or charcoal is the principal ingredient of wood and of all vegetable matters: the object to be aimed at is therefore to increase, instead of to diminish, the quantity contained in the sap; and the chemical process to which this fluid is submitted in the leaves, though analogous to that performed by the lungs, so far as it prepares the sap for being assimilated to the plant, is rather opposed to it, so far as regards its chemical results.

We animals, the most favored part of the creation, endowed with the faculty of locomotion, require to be of a lighter structure than our tough woody neighbors who are attached to the soil; and, in order to move about with facility, it is necessary for us to disencumber ourselves of part of the carbon we consume in feeding on vegetables; and a man you know, exhales in breathing no less than 11 oz., of charcoal per day; whilst the vegetable kingdom, far from suffering from excess of carbon, requires its store to be augmented.

Emily. Ah! this is what I have heard spoken of as one of the most beautiful dispensations of Providence: the vegetable creation purifies the atmosphere, by absorbing the carbon with which it has been contaminated by the breath of animals.

Mrs. B. Just so; but let us examine these wonders a little more narrowly, and trace the steps by which they were brought to light.

425.—What further does Mrs. B. say of this analogy? 426.—What question does Emily ask concerning the effect produced on plants by the atmospherical air so far as relates to the carbon? 427.—What is the reply? 428.—How much carbon does a man exhale in a day? 429.—How is the atmosphere purified after having been contaminated by the breath of animals?

Mr. Sennebier covered a plant which was growing in a pot of earth with a glass bell full of water; and, in the course of a few hours, found a quantity of air within the bell. Whence came this air? Did it proceed from the plant or the water in which it grew? He repeated the experiment with water which had been boiled, for the purpose of depriving it of its air, and in this instance no air was produced in the bell.

Caroline. Of what nature was this air?

Mrs. B. Dr. Priestley ascertained that it consisted of oxygen gas, and conceived that it was produced by the decomposition of the water, which, you know, is composed of oxygen and hydrogen; but then he could not understand why boiled or distilled water, which contains as much oxygen as rain or spring water in their natural state, should not produce this air in the glass bell.

At length Mr. Sennebier, in the prosecution of his experiments, discovered the mysterious origin of this air to be in the carbonic acid, which water, in a natural state, always contains. I trust that you have not so far forgotten your lessons of chemistry, as not to recollect that carbonic acid is composed of oxygen and carbon: the plant absorbs this gaseous acid. It is decomposed in the leaves by the sun's rays: the carbon, which it is essential to the plant to retain, is deposited; and within it the oxygen, which it does not require, flies off by the stomas.

Caroline. Then the little vegetable mouths breathe out pure oxygen, and retain the carbon: this is just the reverse of the operation performed in the lungs.

Mrs. B. You may prove this by a very neat experiment. Place two glass jars over the same water-bath, with a means of communication through the water; fill one of them with carbonic acid, and put a sprig of mint in the other. After some time, a vacuum will be produced in the upper part of the jar of carbonic acid; and a quantity of oxygen gas, corresponding exactly to the quantity of carbonic acid which has disappeared, will be found in

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430.—What experiment was made by Sennebier? 431.—How did Dr. Priestley suppose this air was produced? 432.—What was there about it which he could not understand? 433.—How was Mr. Sennebier finally enabled to ascertain the source of the air contained within the bell? 434.—What is shown by the experiment of the two glass jars over the same water bath?

the jar containing the sprig of mint. And this cannot be accounted for otherwise than by supposing, that the carbonic acid has been absorbed by the mint, decomposed by its leaves, the carbon retained, and the oxygen evaporated.

M. de Saussure has succeeded in measuring the quantity of carbon which plants thus acquire. He transplanted fourteen periwinkles into vases, seven of which he watered with distilled water, and the remaining seven with water in its natural state. After some days he analysed these plants, and found that the former had not made any acquisition of carbon, whilst the latter had acquired a considerable addition of that substance; their wood being one-sixth heavier than that of the former.

Emily. And the periwinkles, which had augmented in weight, had, I suppose, alone given out oxygen by their stomas.

Mrs. B. No doubt; but, in making these experiments, attention must be paid to expose the plants, not only to broad daylight, but, if possible, to the full force of the sun's rays; for the solar light is absolutely necessary to the process of decomposing the carbonic acid. During the night the vegetable laboratory is employed in a very different process; for, in the dark, plants absorb instead of exhaling oxygen.

Caroline. You alarm me, Mrs. B.: this is a sort of Penelope's labor, to destroy during the night the work done in the day. And how is the atmosphere to be purified by these means?

Mrs. B. It is true that this apparent inconsistency requires some explanation. You must observe, that the solid nutritive particles dissolved in the sap, whether of animal or vegetable origin, are combined with a considerable quantity of carbon. The sap therefore contains carbon in two states: in the one gaseous, combined with oxygen, and mixed with the water of the sap; in the other combined with different solid ingredients, but dissolv-

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435.—How did Saussure ascertain the quantity of carbon acquired by plants? 436.—What was the result? 437.—Why is it necessary that this experiment be made in full day light? 438.—What different process takes place in the night with plants? 439—If plants, so far as absorbing and exhaling the gases is considered, reverse in the night what they do in the day, how is the atmosphere to be purified?

ed in the water of the sap. The carbonic acid, we have already observed, is decomposed in the leaves, the carbon is retained, and the oxygen thrown off; but what becomes of the carbon contained in the animal and vegetable matter which the sap holds in solution?

Caroline. I suppose it is assimilated to the substance of the plant, together with the other nutritive ingredients which the sap holds in solution.

Mrs. B. No, that cannot be, for, in order to render carbon fit to be assimilated, it appears to be necessary that it should previously be combined with oxygen, and afterwards separated from it.

Caroline. Is there not something paradoxical in this? How can it be necessary that the carbon should be combined with oxygen, merely for the purpose of being separated from it?

Mrs. B. It is very possible that this chemical process may produce a more minute subdivision of the particles than any mechanical operation could effect, and thus prepare it for being assimilated to the plant.

Caroline. Oh, then, now I guess it. During the night the leaves absorb oxygen, to combine with this carbon, and convert it into carbonic acid; and, when the sun rises, this acid is decomposed, the carbon deposited in a state fit to be assimilated, and the oxygen escapes.

Mrs. B. You are right; and as the decomposition of the carbonic acid, which existed in that state in the sap, takes place at the same time, these two operations, being both similar and simultaneous, are confounded together. But, so far as regards the purification of the atmosphere, it is necessary to distinguish them; for, in the first instance, the oxygen exhaled is a mere restoration to the atmosphere of oxygen which had been taken from it during the night; whilst, in the latter, the oxygen evolved, being drawn from the soil with the sap, is so much clear gain to the atmosphere.

Caroline. Well, I breathe freely again, since I know that the atmosphere positively acquires oxygen from the

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440.—With what query does Mrs. B. conclude her reply to the above question? **441.**—How does Caroline answer it, at first? **442.**—Why is not this a correct answer? **443.**—What is the correct answer which she afterwards does give? **444.**—In what respect are these two operations confounded together? **445.**—In what respect are they to be distinguished from each other?

vegetable kingdom. The portion absorbed during the night, I suppose, is but inconsiderable.

Mrs. B. Not so trifling as you seem to imagine; but, since the whole quantity is restored to the atmosphere during the day, you need not apprehend any dangerous results from its abundance. The Stapadra, the plant which absorbs least, takes in a quantity nearly equal to its own volume during a night; and the apricot tree, which is at the other extremity of the scale, absorbs eight times its own volume of oxygen gas.

Succulent plants absorb the least, having the fewest stomas; and, after them, plants which grow in marshes; then evergreens; and, finally, those plants which shed their leaves in autumn absorb the greatest quantity.

Emily. It is this, I suppose, which renders it unwholesome to keep plants in a bed-chamber?

Mrs. B. It is; but, besides this, I should tell you that those parts of plants which are not green, such as the brown stems and branches of a tree, and also the flowers, absorb oxygen both night and day, but in such very minute quantities, as not sensibly to deteriorate the air.

Let me hear, now, if you can recapitulate the substance of our conversation.

Emily. The sap rises in plants through two different channels: that which is destined for the nourishment of buds, in shoots of the first year, passes near the pith, and is thence conveyed by appropriate vessels through the wood to the buds; that which is to feed the plant in general, rises through the alburnum, and is elaborated in the leaves.

Mrs. B. Very well; and in what does this elaboration consist, Caroline?

Caroline. In preparing the sap to be assimilated to the plant by evaporating great part of the water, and increasing the quantity of carbon. The sap contains carbon in two states: first, in that of carbonic acid; secondly, com-

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446.—How much oxygen does the stapadra absorb in a night? **447.**—How much does the apricot tree? **448.**—What is the order in which different plants absorb oxygen, so far as the quantity is considered? **449.**—What reason can be deduced from the foregoing remarks to show that plants are unwholesome in a bed-chamber? **450.**—What further remark in relation to the same subject does Mrs. B. make? **451.**—By way of recapitulation what account does Emily give of the rising of the sap in plants?

bined in animal and vegetable matter. In the first state the sun's rays decompose the acid, the carbon is deposited, and the oxygen which flies off purifies the atmosphere; in the second state, oxygen is absorbed during the night, and combines with the carbon, with which it forms carbonic acid; this, during the day, is decomposed, and the oxygen restored to the atmosphere. Thus vegetation serves as a counterpoise to the deleterious effect of the respiration of animals.

Emily. And should we not add to the contamination of the air by combustion, Mrs. B.? for oxygen is also absorbed in that process?

Caroline. The air of a forest must then be much more wholesome than that of a town, where so many human beings and animals are continually breathing out carbonic acid, and where such numberless combustions are robbing the atmosphere of oxygen.

Mrs. B. No; the constant motion of the air so rapidly restores the equilibrium, that it has been found, by the most accurate chemical experiments, that the air of a crowded city contained precisely the same quantity of oxygen as the finest air of the country. I do not mean to say that the atmosphere is not more impure and unwholesome in a large town; but this arises from the smoke, and variety of exhalations, which do not circulate so rapidly as the oxygen gas.

The air in a forest is, on the other hand, far from being considered as healthy; the trees impede the circulation more than the houses in a town, the latter being, in some measure, ventilated by the currents of air which flow through the streets.

Caroline. But, then, consider the pure breath of the green leaves in a forest.

Mrs. B. The exhalations arising from the stagnant waters, and the putrefaction of the dead leaves which remain floating in the confined air, more than counterbalance that advantage, and render a dense forest an unwholesome spot to inhabit.

452.—How does Caroline recapitulate what had before been said of the elaboration of the sap? 453.—What does Caroline say of the comparative healthfulness of the forest and the town? 454.—Why is her opinion incorrect? 455.—From what arises the unwholesomeness of the populous city if not from the want of oxygen in the air? 456.—And why is it unhealthy in the forest, if vegetation conduces to the purity of the air?

CONVERSATION VI.

ON CAMBIUM, AND THE PECULIAR JUICES OF PLANTS.

Mrs. B. Having traced the sap in its ascent to the extremity of the leaves, and converted it, by the changes it undergoes in that chemical laboratory, into an homogeneous liquid adapted to the nourishment of the plant; we must now, following it in its descent, observe in what manner it performs this office.

The sap, thus changed, assumes the name of Cambium or returning sap, and passes into another system of vessels which convey it downwards, chiefly through the liber, or most internal layer of bark, and a small portion through the alburnum, or young wood; and, as it traverses the several organs, it deposits in each the various matters requisite for their sustenance.

Caroline. Having compared the ascending sap to chyle, Mrs. B., we may find a still greater analogy between the cambium and blood, into which chyle is converted, after having passed through the heart and lungs, and been rendered fit to nourish the animal frame.

Mrs. B. We have already observed, that the chemical changes which take place in the leaves, in order to convert the sap into cambium, are in many respects analogous to those which take place in the heart and lungs, in order to convert the chyle into blood.

Emily. True: in both cases the atmosphere is the agent; with this difference, however, that it carries off carbon from the animal system, while it is the means of accumulating carbon in that of vegetables.

Caroline. But if the cambium descends through the liber, how does it find its way in endogenous plants, which have no bark?

Mrs. B. Its passage in monocotyledons has not been well ascertained. It is probable, that the fibres of the

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457.—By what name is the sap called when it descends? **458.**—Through what parts of the plant does it descend? **459.**—What has already been remarked of the chemical changes which take place in sap? **460.**—Is it known through what portion of the monocotyledons sap descends?

wood are the medium through which the sap both ascends and descends; but you may recollect that it is not well ascertained, whether the ascending sap rises through the vascular or cellular system, or through the interstices between them; and the vessels which convey the descending sap being so minute as barely to be discernible by the aid of a microscope, it is impossible to examine them with accuracy. Besides which a still greater difficulty attaches to the investigation of the vessels of endogenous plants: those which grow in our climates being too small to enable them to acquire that degree of vigor which is requisite for a complete developement of their organs.

Caroline. We shall not have the same difficulty to account for the descent of the cambium, as we have had for the ascent of the sap; since it obeys the laws of gravity and descends by its own weight.

Mrs. B. That is a general cause of the descent of cambium, no doubt; but in the weeping-willow, and many other trees whose branches are pending, some additional cause is required to produce the motion of the cambium, since it must rise to return into the stem. It has been ascertained that agitation facilitates and accelerates this motion, and consequently increases the vigor of vegetation; for the more rapidly this nutritive fluid circulates through the several organs, the more frequently it will deposit its nutritive particles in them. Mr. Knight has made a variety of interesting experiments on this subject. He confined both the stem and branches of a tree, in such a manner that it could not be moved by the wind. The plant became feeble, and its growth much inferior to that of a similar tree, growing in a natural state. Mr. Knight confined another tree, so that it could be moved only by the north and south winds, and obtained the singular result of an oval stem; the sides accessible to the wind growing more vigorously than

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461.—What is probable? 462.—What further difficulty attaches to the investigation of the vessels of endogenous plants? 463.—What is a general cause of the descent of cambium? 464.—In what trees must there be some other cause? 465.—What has been ascertained to produce an accelerated motion of cambium, and consequently an increased vigor in vegetation? 466.—What was the first experiment made by Mr. Knight with its result, in relation to this subject? 467.—What was the second one with its result?

those sheltered from its influence. Every species of restraint, and, especially such as tends to render plants motionless, impedes their growth. Stakes by which young trees are propped, nailing them to walls or trellises, greenhouses, or confined situations where this salutary air has not free access, check and injure the vigor of vegetation, and render plants diminutive and weakly.

Caroline. But if young trees were unsupported, they would in all probability be blown down by the first violent wind.

Mrs. B. The stake, it is true, is often necessary; but then it must be considered as a necessary evil, and remembered that, whenever it can be avoided, the plant, will thrive better without it. It should never be fastened so tightly as to prevent all motion, for the exercise which the wind gives to young trees is no less salutary than that which a mother gives to her infant; but it is true that the wind is often a rough nurse, over whom it is prudent to keep a watchful eye.

Caroline. Then nailing fruit-trees against walls must be prejudicial to their growth?

Mrs. B. No doubt; but the advantages resulting from the shelter afforded by walls and the heat reflected by them, more than compensate for the bad effects of confinement—for such fruits, at least, as require a higher temperature to ripen them than is to be met with in our climate; but, when the temperature is genial to the plant, standard trees, growing freely in their natural state, produce the finest fruits. Greenhouses and hothouses, however confined, are asylums necessary in winter for the culture of plants of a warmer climate; for though gentle breezes may be beneficial to fan delicate plants, we must shelter them from the inclemency of boisterous winds.

The cambium, we have observed, descends almost wholly through the liber, or most internal and youngest layer of the bark; if, therefore, you cut a ring completely through the bark, this fluid will be arrested in its course, and, accumulating around the upper edge of the

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468.—How are young trees affected when confined by stakes? 469.—When stakes are necessary how should they be used? 470.—What advantages may result from the nailing fruit trees against walls? 471.—Under what circumstances will standard trees produce the finest fruits? 472.—What is said of the use of Greenhouses?

intersected bark, cause an annular protuberance. The descent of the cambium thus being obstructed, it will accumulate in that part of the tree above the intersection, afford it a superabundance of nourishment, creating a proportional vigor of vegetation, and a corresponding excellence and profusion of produce.

Emily. Would it not then be a good mode of improving the produce of fruit-trees?

Mrs. B. This operation, which is called ringing, has been tried on the branches of fruit-trees, and, I understand, often with success; but I should conceive that the tree must be ultimately injured by the operation; for, if you confine to one part of a plant the food which was destined for the nourishment of the whole, you interfere with the order of that wisest and best of agriculturists—Nature. When interrupted, however, in her original course, she is fertile in expedients to accomplish by collateral means her destined purposes. I observed that some small portion of the cambium descended through the alburnum, which is contiguous to the liber. When the annular section is made on a branch, a much more considerable quantity forces its passage through this channel, and, by affording the young wood an unusual supply of nourishment, renders it harder and heavier below than above the intersection.

Caroline. But if the vegetation of the tree above the annular section is improved, and the wood beneath it better nourished, what part of the plant suffers by this operation?

Mrs. B. Not any part during the season the annular section is made; the evil is reserved for a later period, as I shall explain to you.

The cambium being thus diverted from its course, the greater part being forcibly detained above the annular section, and what little makes its escape descending through another channel, the bark is wholly deprived of

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473.—What will be the effect if a ring be cut completely round a tree when the cambium is descending? **474.**—Has it been thought that fruit trees have been benefited by this mode of ringing. **475.**—When the cambium is thus interrupted, what other mode of descent is there? **476.**—How is the quality of the wood affected by ringing? **477.**—What parts of the tree are not annually formed from this interruption of cambium?

its natural sustenance; the consequence of which is, that the new layers, both of alburnum and of liber, which should be annually produced by the descent of the cambium, are not formed.

The following season, therefore, the sap, instead of rising through the soft and tender vessels of the newly-formed alburnum must ascend through the alburnum of the preceding year, under the additional disadvantage of its being unusually hardened by the superabundant quantity of nourishment it has received.

This artificial mode of rendering alburnum hard and mature, suggested the idea of stripping timber-trees of their bark a year or two previous to their being cut down, in order to harden the young external layers of wood, by forcing the whole of the cambium to find a passage through them, and thus convert the alburnum into perfect wood before the natural period. The experiment, when first made, appeared to answer the most sanguine expectations. The cambium, instead of forming new layers of tender wood under shelter of the bark, forced its way through the alburnum, giving it in one season the hardness and consistence of perfect wood. But it was afterwards discovered that the wood thus artificially matured, by being stripped of its bark, and exposed naked and defenceless to the inclemency of the weather, to the encroachment of lichens and creeping plants, and to the attacks of insects and reptiles; receives injuries, which more than counterbalance the advantages of a precocious maturity; and render it totally unfit for building.

Let us now turn our attention to the composition of the cambium, which subsequently becomes a component part of the plant.

We have observed, that about two thirds of the water absorbed by the roots is evaporated by the leaves, one third only remaining in the plant. This latter portion exists in vegetables in two states: in the one it retains

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478.—What is the consequence in the following season? 479.—What method of prematurely hardening timber trees has sometimes been practised? 480.—What was at first supposed to be the result? 481.—What disadvantage was afterwards discovered? 482.—In how many different states does the sap exist which remains in the plant?

its liquid form; in the other it is decomposed, and enters into a chemical combination with various parts of the plant, so as to be identified with its solid tissue, and in such a manner that the dessication will not make it reappear.

Emily. But by a chemical analysis would you not discover it?

Mrs. B. No; because it no longer exists in the form of water, but is resolved into its constituent elements, oxygen and hydrogen.* I trust you recollect that water is a combination of these two principles.

M. de Saussure weighed the water with which he watered a plant; and after the most careful investigation by mechanical means, both by preserving the water evaporated, and obtaining that which remained in the plant by dessication, he could not discover above five-sixths of the water he had given to the plant.

Emily. And is it not known under what form this sixth portion of water exists, in its new combinations in the plant?

Mrs. B. The oils and resins with which plants abound contain a very large proportion of hydrogen. There are other vegetable substances which abound with oxygen; the water, therefore, which so totally disappears, is doubtless resolved into its two constituents, oxygen and hydrogen, supplying the oils and resins, and the other juices, with such proportions of these elements as they respectively require.

Carbon is obtained by plants from three different sources: from carbonic acid contained in the sap; from animal and vegetable matter dissolved in that fluid; and from the atmosphere.

Caroline. Having so many means of procuring carbon, no wonder that plants should lay in so large a stock.

Mrs. B. What part of a plant would you imagine contained the most carbon?

* See Conversations on Chemistry, Con. VIII.

483.—What are they? 484.—Why cannot that which exists in the second state be discovered? 485.—What experiment was made by Saussure upon the subject? 486.—What question did Emily ask, founded on this experiment? 487.—What is the answer of Mrs. B? 488.—In how many different ways is carbon in plants obtained?

Caroline. I should think the wood, which burns so well because it consists almost wholly of charcoal.

Emily. And yet the leaves in which the carbon is deposited, when separated from the oxygen, should contain more of that ingredient than the wood.

Caroline. In that case leaves should be used for fuel in preference to wood.

Mrs. B. Emily is right: the green parts of plants contain the most carbon; and dry leaves make an excellent combustible, but they are too large in volume to form a convenient one.

After the leaves, the bark, especially when green, abounds most with carbon; and, lastly, the wood: the alburnum or white wood contains the least.

Caroline. Green wood then should be most combustible; and yet it is noted for burning badly.

Mrs. B. By green wood is commonly meant wood not sufficiently dried. Whatever quantity of carbon wood contains, it cannot prove a good combustible, unless the water, and other juices injurious to combustion, first be evaporated.

The alburnum, when well dried, burns briskly, because it contains a greater quantity of hydrogen than perfect wood; and it is the combustion of hydrogen, you may recollect, which produces flame: but, owing to its deficiency of carbon, alburnum gives out less heat.

The ascending sap, we have observed, contains also a great variety of earthy and alkaline particles; such as magnesia, lime, silex, potash, and soda. When the evaporation from the leaves takes place, these bodies are deposited, and become constituent parts of the cambium, and are thus conveyed to their several destinations.

The most soluble of the earthy salts such as lime and magnesia, are naturally most abundant in the sap; and when a plant is burnt, the earths, being incombustible, form the materials which constitute its ashes.

The alkaline salts, potash and soda, being also of a soluble nature, are conveyed in considerable quantities

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489.—Which parts of plants contain most carbon? 490.—Which next; and which least? 491.—When will wood become a good combustible? 492.—Why does alburnum burn so well? 493.—What is said of the alkaline particles with which sap is impregnited? 494.—What earthy salts in wood constitute its ashes when burnt?

into the sap; when this undergoes evaporation, a large portion of these salts is deposited in the leaves, the rest remains in solution in the cambium, incorporates with the plant, and, after combustion, may be discovered in its ashes.

The silicious particles, contained in the plant being, on the other hand, nearly insoluble, enter very little into the composition of the cambium, the greater part remaining in the leaves, where it has been deposited by the evaporating sap; and the fall of the leaf is attributed to the accumulation of this hard earthy matter, which in the course of time clogs and indurates their vessels, so as to render them impervious to the juices requisite to their vegetation. The vessels composing the petiole, in which they are so closely bound together, are more especially liable to suffer from these obstructions: unable any longer to transmit nourishment to the leaf, the petiole dries, withers, and falls off; and the plant is thus disburdened of a useless substance, the accumulation of which would be prejudicial to its growth.

Caroline. It must be confessed, that it is rather a serious remedy to destroy the organ, in order to get rid of the inconvenience with which it is afflicted.

Mrs. B. You must consider, that when Nature constructed these organs in so frail and delicate a manner, it was with the intention that they should be annually renewed: it becomes expedient, therefore, to get rid of the old leaves, in order to make way for the new ones.

Azote, an ingredient chiefly of the animal kingdom, is to be found also, in very small quantities, in vegetables: they obtain it both from the atmosphere, of which it forms the chief constituent part, and from the animal matter of manure.

From the cambium, with all the component parts of which you are now acquainted, a great number of different juices are secreted, such as oil, resins, gum, &c.

Caroline. Just as tears and saliva are, in the animal economy, secreted from the blood.

495.—What is said of the potash and soda in wood after combustion takes place? 496.—To what is the fall of leaves attributed? 497.—What is said of the vessels composing the petiole in relation to this subject? 498.—What does Mrs. B. say of the annual destruction of leaves? 499.—What is said of azote in vegetables? 500.—What juices are secreted from cambium?

Mrs. B. There is, it is true, a considerable analogy between the animal and vegetable secretions: they are both drawn from the general nutritive fluid, and each by the means of glands; but, owing to the extreme minuteness of the organs of plants, the vegetable anatomy is very much behind that of the animal kingdom.

Emily. In small herbs this must necessarily be the case; but in large forest-trees, I should have supposed that the organs, when fully developed, would have been of greater magnitude than those of animals.

Mrs. B. No; the organs of the oak are not larger than those of the family of mosses. Nor is this singular, if you consider that the leaves and fruit of forest-trees are not, in any respect, proportioned to the size of the plant: —you do not forget the fable of the Pumpkin and the Oak. Every leaf and every flower must contain a system of organs, adapted to the various operations it has to perform, without any reference to the general size of the plant. In the animal economy we are still unable to discover the mode in which the glands elaborate their secretions from the blood: how much less, then, can we expect to penetrate the secret, in a system where the organs themselves are frequently so minute as to elude our sight, the largest not being more than one-twentieth of a line in diameter, and there are some, so small as not to exceed the one-hundred-and-fiftieth part of a line in dimension!

Many ingenious hypotheses have been proposed to account for the secretory action of the glands, both in the animal and vegetable economy, but none have hitherto proved satisfactory. That which appears least objectionable, is the agency of electricity; but it must be owned that the chief argument in favor of this agent is, that we are not yet sufficiently acquainted with its powers to prove the hypothesis which rests upon it to be erroneous.

The chemistry of vegetables, on the other hand, is more advanced than that of the animal kingdom; because the

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501.—What does Mrs. B. say of the analogy between the animal and vegetable secretions? 502.—What is said of the comparative size of organs in different vegetables? 503.—What is it said that every leaf and every flower must contain? 504.—Why are we not to expect understanding the mode of elaborating secretions in vegetables? 505—What is the largest and what is the smallest of their organs? 506—What hypothesis of secretory action appears least objectionable?

great and mysterious secret, *life* performs a less important part in the vegetable than in the animal economy.

The secretions separated from the cambium by the glands are of two descriptions: the one, destined to remain in the plant, is distinguished by the name of internal secretions, and is elaborated by glands of a cellular form; the other, intended to be conveyed out of the plant as useless or detrimental to it, is for this purpose secreted by glands of a vascular form.

The internal secretions are milk, resins, gums, gum resins, manna, essential oils, and fixed oils.

Emily. These are substances with which we are in some measure acquainted, as I believe you explained their chemical composition in our Conversations on Chemistry.

Mrs. B. True; but we are now to examine them rather in a different point of view; and I do not think I then mentioned the secretion of vegetable milk. There are three species of this fluid: the first is that which contains opium, and is extracted from the juice of poppies, lettuces, and some other plants; it is almost always white, but sometimes assumes a reddish or yellowish tint.

The second contains caoutchouc, or elastic gum; which, however different in appearance in the artificial state in which we are acquainted with it, is naturally white and liquid.

It is obtained from several different species of trees in tropical climates, but principally from that which bears the name of Hevea.

When an incision is made in the stem, it flows from the wound, and is collected on the surface of small moulds of clay in the form of bottles, to which, being of a glutinous nature, it adheres. It acquires consistence and blackens in drying, and, when the coating of caoutchouc is of a sufficient thickness, it is beaten to pulverise the mould, which is then shaken out.

507.—Why is the chemistry of vegetables more advanced than that of the animal kingdom? 508.—The secretions separated from the cambium are of two descriptions—what is said of them? 509.—What are the internal secretions? 510.—How many kinds of vegetable milk are there? 511.—Which is the first? 512.—What is the second kind? 513.—From what is it obtained? 514.—How is it obtained and prepared?

The third species of vegetable milk resembles that of the cow, and is the produce of a tree in America, thence called the cow-tree. Mr. Humboldt informs us, that it grows in rocky and unfruitful districts, little calculated for the pasturage of cattle. On the barren side of a rock it rises with coriaceous and dry leaves, which are, during many months of the year, not moistened by a single shower. The branches appear dead and dry; but, when the trunk is pierced, there flows from it a sweet and nourishing milk. At sunrise, this vegetable fountain is most abundant. The natives are seen hastening from all quarters, furnished with large bowls to receive the milk, which grows yellow, and thickens at the surface. This tree is of the family of the Sapoteæ.

Caroline. What a delightful resource it must be to the people of that country, who may repose beneath its shade, while they refresh themselves with the grateful beverage it produces! Does it also yield fruit?

Mrs. B. Every tree yields fruit of some kind, otherwise it could not continue its species; but that of the cow-tree is as yet unknown.

Resins are volatile oils, peculiarly modified by the action of oxygen. Pitch, tar, and turpentine are the most common and the most useful juices of this description; they exude from the pine and fir trees, and are of a thick viscous consistence. Copal, mastic, and frankincense are resins of a more refined nature: the two former, dissolved in oil, form excellent varnishes; and frankincense, you know, is the perfume burnt in all the Catholic churches. The resinous juices flow always in a descending direction: when an incision is made in a tree which yields them, they trickle from the upper edge of the wound.

Gum is a mucilaginous secretion, common to all leguminous plants, and to a great number of trees bearing stone-fruits, such as the cherry, the peach, and the apricot: whenever an accidental fissure is made in the stem, it exudes from it.

515.—What is the third kind of vegetable milk? 516.—What description is given of the cow-tree? 517.—What is necessary that trees continue their species? 518.—What are resins? 519.—What are the most common ones? 520.—What is said of copal, mastic, and frankincense? 521.—In what direction do resinous juices flow? 522.—What is said of gum?

Gum-arabic is obtained from the acacia of Arabia by incisions made in the stem.

Gum-tragacanth exudes naturally from the stem of *Astragalus*. This secretion, which accumulates during the night, when little or no evaporation takes place, swells the wood which presses against the bark, and, this dry coating not being susceptible of a similar distention, the gum forces its way through it.

Gum-resins appear to be a mixture of the two vegetable products from which their name is derived, and are common to all umbelliferous plants.

Manna is a saccharine secretion, which abounds in the small-leaved ash of Calabria. It is to be found also, in smaller quantities, in several other trees, such as the larch and the willow.

The essential or volatile oils bear a strong resemblance to resins; they are enclosed in small vesicles, whence they are extracted by pressure. They are imprisoned, in this manner, in the rind of the orange and the bark of the cinnamon tree, in the wood of the sandal-tree, and in a great variety of leaves, such as those of the geranium and the orange, and in flowers of almost every description. In a word, there is scarcely any part of a plant from which essential oil may not be extracted, excepting the seed, from which it is absolutely excluded.

Fixed oils, on the contrary, are almost exclusively contained in the seed, where they constitute the most appropriate nourishment for the embryo plant. There is, I believe, but one exception to this rule, the olive, where the oil abounds not only in the seed, but also in the pulp of the fruit, whence it is expressed to supply our tables, or for the purpose of combustion. Nut-oil, linseed-oil, and all the fixed oils, are not, like the essential oils, enclosed in appropriate vessels, but are lodged in every interstice of the seed. We shall speak more fully of this when we come to examine the organization of this asylum of the embryo plant.

523.—From what and how is Gum-arabic obtained? 524.—What is said of Gum-tragacanth? 525.—Of what do gum resins appear to be mixtures? 526.—What is said of manna? 527.—What said of volatile oils, and in what are they contained? 528.—In what are fixed oils contained? 529.—What exception is there? 530.—What is said of nut-oil, linseed-oil, and of other fixed oils?

Let us now proceed to the excretory secretions: they are of much less importance than the preceding, and consists chiefly of vapors and gases exhaled from flowers. Among these we distinguish the vapor of the Fraxinella, which is elaborated by glands sufficiently large to be visible, and is very combustible.

Emily. I recollect having seen it burn, by approaching a taper to it; but is not this vapor similar to the exhalations of the odor of plants?

Mrs. B. No; the odors of plants are undoubtedly an excretory secretion, but are not generally of a combustible nature. They are of various descriptions, but it is difficult to determine in what manner to class them, as they affect the olfactory nerves of different people in so different a manner: they have been attempted to be distinguished by the name of aromatic, stimulating, penetrating, sweet. Flowers, with some few exceptions, (such, for instance, as the rose and the violet,) exhale their perfume only as long as the plant is living; that which proceeds from the bark, or other parts of the plant, continues to be emitted after death.

Flowers having an ambrosial smell, exhale it only in the evening, after sunset; those which have the odor of musk are always of a yellowish purple color, and of a dull appearance, corresponding, it is said, with the deleterious nature of their perfume.

The smell of flowers, in general, is considered to be more insalubrious to a person sleeping than awake. Whether it be, that, in the latter case, the animal frame has a more energetic power of resistance to deleterious effects, or from some other cause, is not ascertained.

Emily. May not this difference arise from plants giving out oxygen during the day, and absorbing it during the night?

Mrs. B. No; the spasmodic effect produced on the nervous system by the perfume of flowers is quite

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531.—Of what do the excretory secretions consist? **532**.—By what name have the odors of plants been distinguished? **533.**—What is said of flowers as to exhaling perfume before and subsequent to their death? **534.**—What is said of flowers having an ambrosial smell, and of those which have an odor of musk? **535.**—What is said of the smell of flowers to persons asleep?

independent of those operations; and it is sleeping or waking, whether in the daytime or the night, that the difference I mentioned has been observed.

Besides the water which plants exhale from the leaves, there are several peculiar juices elaborated by glands situated on the surface of the leaves. These are furnished with hairs, at either the point or base of which they grow, and may be compared to the hairs which grow at the orifice of the pores of our skin.

Emily. How extremely minute must those glands be which can be supported on so slender and frail a stem!

Mrs. B. You may thence form some idea of the diminutive size of the vegetable organs in general. When the secretory gland is situated on the summit of the hair, the liquid it secretes is of an innocent nature; but when situated at the base, the secretion is acrid, caustic, and poisonous.

Caroline. This is, no doubt, the case with nettles, which pour their poisonous secretions on the skin, and raise it into blisters.

Mrs. B. The poison must penetrate beneath the cuticle in order to produce this effect; the hair is the instrument which gives the wound, and the poisonous juice is then poured into it.

Emily. This is just like the sting of a serpent, who inflicts a wound and then ejects his poison into it. But what is the reason that nettles do not sting when wetted with rain?

Mrs. B. Because the hair, when softened by moisture, has not sufficient strength to perforate the skin; and, unless a puncture be made, the secretion cannot insinuate itself beneath the skin, and no sting is felt. Stinging plants can also be handled with impunity after death, if dried, for, though in this case the instrument may be capable of wounding, the poisonous juice is no longer fluid, and cannot flow into the puncture.

536.—Why may it not be owing to plants giving out oxygen during the day, and absorbing it during the night? 537.—With what are the glands situated on the surface of the leaves furnished, and what is said of them? 538.—What is the difference in the liquid secreted, whether it be from the summit or the base of the hair? 539.—In what manner are nettles able to produce such effects, when applied to one's flesh? 540.—Why are not nettles able to sting when wetted with rain? 541.—What is said of stinging plants when dead?

Emily. Then should we not feel the infliction of the wound, although we might escape the smarting of the blisters?

Mrs. B. The instrument is so minute and delicate, that the wound it inflicts would not be felt were the skin not inflamed and blistered by the poison.

The nectar of flowers, the bloom of fruits, and the vicious coating of aquatic plants, which preserve them from the element in which they grow, may all be considered as excretory secretions; but we will postpone their examination till we enter upon the subject of flowers and fruits.

We have now traced the sap, from its first entrance into the roots, throughout the whole frame of the plant; we have examined its component parts, the chemical changes it undergoes in the leaves, its subsequent descent under the form of cambium, and the various peculiar juices which are secreted from this nutritive fluid, as it returns from the extremity of the leaves into the roots.

Emily. But is the whole of the sap consumed in the performance of these several operations, and does no part of the cambium return through the roots into the earth?

Mrs. B. It is the opinion of M. De Candolle, founded on experiments he has made on this point, that a small residue of the cambium exudes from the roots into the ground.

In planting, it has long been observed that trees of a different species from those which previously occupied the ground, thrive better than a repetition of those of the same kind: whence it is inferred that the exudation of one species of plant, though it may injure the soil for other individuals of the same species, may possibly afford appropriate nourishment for plants of another description. But this is a question we shall refer to at some future period.

Having now concluded our examination of the structure of a plant, and of the mode in which it is nourished, I shall proceed next to observe in what manner it is af-

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542.—Why might we not feel the wound, although we escape the effects of the poison? 543.—What is said of the nectar of flowers, the bloom of fruits, and the viscous coating of aquatic plants? 544.—Does any part of the cambium return through the roots into the earth? 545.—What has been long observed in the planting of trees? 546.—What reason is assigned for this? 547.—Of what subject is Mrs. B. next to treat?

fected by the external bodies with which it is in contact, such as light, heat, the atmosphere, the soil, &c. This will enable you to acquire some information respecting the culture of plants; and though I do not aim at making you adepts in agriculture, yet I consider the application of botany to that science as the most useful and the most interesting point of view in which it can be studied.

Caroline. And it must be much more amusing than the common mode, of studying the classification of plants.

Mrs. B. Classification must always be respected in science. It is impossible to acquire any clear ideas in any branch of knowledge without its aid; but it is true that in botany it is sometimes held in too high estimation. In the eagerness of pursuit, the student is apt to forget that classification is but the means, not the end to be attained.

M. De Candolle's mode of classification is more simple than that of any preceding botanist; still you must expect it to afford you instruction rather than amusement. But we shall not treat of it till we have examined the various organs of the flower on which it is founded.

Caroline. And when are we to learn the history of the flower, Mrs. B.?—that part of botany which I once thought comprised the whole of the science?

Mrs. B. The flower is the asylum, in which the seed, destined for the reproduction of the plant, is lodged and cherished. We shall examine the flower and the seed, therefore, in immediate succession, when we enter on the subject of the reproductive powers of plants.

CONVERSATION VII.

ON THE ACTION OF LIGHT AND HEAT OF PLANTS.

Mrs. B. In examining the effect of external bodies on plants we shall begin with light, which may be considered as acting on them in four different ways. The first rays of the rising sun seem to awaken the vegetable creation from its state of repose.

Caroline. You do not mean to infer that plants sleep during the night, Mrs. B.?

548.—Of what advantage will this be? 549.—What does Mrs. B. say of classification in botany? 550.—What was Candolle's mode of classification? 551.—Of what is the flower an asylum? 552.—In how many ways does light act on plants? 553.—What is the first?

Mrs. B. I doubt whether the term sleep be literally appropriate to that state of relaxation and inaction which appears to afford them repose during that season. The leaves and flowers usually change their position as soon as it grows dark; in many plants the leaves drop; in others they close, as well as the petals of the flowers, and are opened by the first rays of the morning sun. The leaves then recommence their chemical operations, the spongioles draw up a provision for their labors, every function which had ceased or diminished during the night is again renewed and the whole plant reanimated. It is this effect, produced by light on plants, which I call being awakened.

Secondly, the direct rays of the sun are necessary to enable plants to decompose carbonic acid gas in any sensible quantities. We have already observed, that in this process the oxygen of the carbonic acid is exhaled by the leaves, and the carbon deposited in the plant: now, it is this deposition which produces their green color. Mr. Sennebier is of opinion, that carbon is not positively black, but of a dark-blue color. The cellular tissue of plants is of a yellowish white; consequently, when those minute blue particles are lodged within the yellow cells, the combination of the two colors produces green, in which the blue or yellow tint prevails, in proportion as the carbon or cellular tissue predominates.

Caroline. That is very curious, and accounts for the pale delicate tint of the spring verdure, when but a small quantity of carbon has been deposited in the leaves; and the deeper shades which plants acquire in summer and autumn, when they have accumulated a greater stock of carbon.

But what is it that produces the change of color at the fall of the leaf, and, indeed, often takes place previous to their fall, when some leaves assume a beautiful red or yellow color?

Mrs. B. Some ingenious experiments have lately been made on this subject by Mr. Macaire. He ascertained that, late in the autumn, when leaves begin to change

554.—When it grows dark, what change takes place in flowers and leaves? 555.—What does Mrs. B. mean by the awakening of plants? 556.—What is the second way in which light operates on plants? 557.—How is the green color of plants produced? 558.—In what way did Mr. Sennebier account for it? 559.—For what does Caroline suppose his hypothesis will account?

their color, they absorb oxygen during the night, but lose the power of giving it out during the day: hence he inferred, that the accumulation of oxygen destroyed the green color and produced the various tints which the autumnal leaf assumes.

Emily. We know the power that oxygen has in changing the colors of metals: it is not therefore, surprising that it should produce effects somewhat similar on plants; but if it is oxygen which gives rise to the red and yellow color of dying leaves, may it not also be the cause of the various hues of living flowers? Mr. Macaire should have prosecuted his researches to have discovered this.

Mrs. B. He did so; and was led by their result to think, that it is to the various quantities and modes of combination of oxygen, that the different colors of flowers is to be attributed.

The third mode by which light acts on plants, is by facilitating, and consequently increasing, their absorbent powers. The more the cause is augmented, the more the effect is increased. Tell me now, what do you suppose would be the result of great intensity of light?

Emily. To be enabled to answer your question, it would be necessary to be acquainted with the plants of tropical climates, where light as well as heat is so much stronger than in our latitudes.

Caroline. It would be more easy, in this mountainous country, to study the plants which grow on their summits, where they are so much more exposed to light than in the valleys or the plain; and I recollect observing, that they are generally of a deeper green, which is no doubt owing to the greater deposition of carbon.

Emily. I have remarked, also, how much deeper the green color of vegetation is in Italy than in England.

Mrs. B. In the tropical climates this difference is still more remarkable. But what is very extraordinary, M.

560.—What causes leaves in autumn to assume a red or yellowish color? 561.—What fact is mentioned by Emily which renders Mr. Macaire's opinion on the color of plants probable? 562.—What further did he suppose in relation to the color of plants? 563.—What is the third mode in which light operates on plants? 564.—What question is asked by Mrs. B. as to the effect of light on plants? 565.—In reply what does Caroline say she has observed? 566.—And what has Emily remarked in relation to the same subject? 567.—Where does Mrs. B. say this difference is more apparent?

Humboldt met with some green plants growing in complete darkness, at the bottom of one of the mines of Freuberg. The mine abounded with hydrogen. Now, whether this gas be endowed with the power of developing the green color, or whether it may enable them to decompose carbonic acid without the aid of light, is a problem which we must leave to more able chemists to resolve. What increases the difficulty is, that carburetted hydrogen gas is a poison no less deleterious to plants than it is to animals.

Another effect of intensity of light, is to render plants remarkably firm and hard of texture, owing both to the accumulation of carbon, a body of a compact solid nature, and to the increased vigor of their powers of absorption, which enables them to incorporate a greater quantity of the earthy matter dissolved or floating in the increased quantity of sap they suck up.

Caroline. But, on the other hand, they must contain a greater quantity of liquid, which could produce a contrary effect.

Mrs. B. Recollect that intensity of light increases the power of evaporation, as well as that of absorption; the plant, therefore, retains no superabundance of liquid, although it acquires more of the solid particles which it held in solution. The compactness and hardness of plants exposed to an excess of light, offer some impediment to their growth; their vessels, deficient in elasticity and flexibility, are not so susceptible of being elongated by the fluids which circulate within them. Mountainous plants are therefore more diminutive in size than those of the plain.

Emily. But this is far from being the consequence of exposure to light in hot climates, where the vigor of vegetation greatly surpasses that of our more moderate temperature, and where plants are in general of much larger dimensions than with us.

Mrs. B. It is to the intensity of heat, rather than of light, that they owe their superiority. When these two

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568.—What extraordinary discovery was made by Humboldt? 569.—What is another effect of intensity of light on plants? 570.—What objection does Caroline make to the theory of Mrs. B. that the hardness of plants is increased by intensity of light? 571.—How does Mrs. B. reply to this objection? 572.—Why are mountain plants diminutive in size? 573.—What objection does Emily make to the reason assigned by Mrs. B. for the diminutive size of mountain plants?

causes act simultaneously on plants, they concur in promoting the vigor of vegetation. The intensity of heat tends to distend the vessels indurated by the deposition of carbon, and to accelerate and give increased impetus to the motion of the sap; which, flowing profusely through these firm yet still elastic vessels, produces a force of vegetation, and a magnitude of dimensions, unknown in our less genial climes.

The mountain plant, on the contrary, is peculiarly exposed to cold; the chilled and languid sap traverses with difficulty the indurated vessels, the circulation of all the juices is checked, and the vigor of vegetation proportionally diminished.

Caroline. And yet the flowers on mountainous plants appear to me unusually large.

Mrs. B. It is an observation which has been frequently made; but I am inclined to think it is an illusion, produced by the comparative diminutiveness of the stem and branches.

There is a third cause of the greater hardness of plants exposed to intensity of light. By assimilating a more considerable quantity of carbon, the plant at the same time decomposes and incorporates a greater quantity of water. It is not known how this operation is performed; but the water, no longer in a liquid form, augments instead of diminishing the solidity of the plant.

Caroline. I should be curious to examine also, the other side of the question; that is to say, the effects of a deficiency of light, such as occurs with plants cultivated within doors, in confined situations, in the shade of forests, &c.

Mrs. B. In the first place, they are pale from not having a sufficiency of carbon to develope their color. In consequence of this deficiency of carbon, their fibres, being soft and feeble, are easily stretched out, and grow to a great length; as you may possibly have seen potatoes, when sprouting in a dark cellar, shoot out weak slender branches, six or eight feet in length.

A deficiency of light diminishes the power of evapora-

574.—How does Mrs. B. answer her objection? 575.—What further is said of the smallness of mountain plants? 576.—What does Mrs. B. say of the size of mountain flowers? 577.—What is a third cause of the hardness of plants exposed to intensity of light? 378.—Why are plants pale growing in the shade? 579.—What other effect attends their growing in the shade, and what is an example?

tion still more than that of absorption, so that the plant retains an excess of liquid, and becomes literally dropsical. This state of saturation diminishes both their smell and their savor. Advantage is taken of this circumstance to soften the flavor of vegetables when too strong; that of celery, for example, is tempered by burying the stem in the ground, and sheltering it from the light, the leaves alone are suffered to appear above ground. In these the green color is developed, while the stem remains perfectly white.

Caroline. But since it is the leaves which occasion the deposition of carbon, I should think the purpose would be more effectually accomplished by covering *them* up with earth also, or by stripping them off the stem. And by depriving the plant of its means of evaporation, you would also increase the retention of sap, and render the plant more tender and less-strongly flavored.

Mrs. B. But such extreme measures would check vegetation, and render the plant diseased, if not actually destroy it.

It is with the view of making lettuces white and tender that they are tied up, so that the external leaves are alone exposed to the light.

Caroline. It is not necessary for the gardener to perform such an operation on cabbages; for Nature takes this precaution so completely, that it is the external leaves only which develope any color, the heart being quite white and tender from a deficiency of carbon and a superabundance of water. Endive is also artificially whitened, and its flavor softened, by being covered with tiles; the green leaves of endive, which have not been thus sheltered from the light are very unpleasant to the palate from their bitterness. But vegetables thus whitened, though tender, are generally crisp, not soft.

Mrs. B. That crispness would have been converted into a hardness approaching to woody fibre, if the plant had not been sheltered from the light. The crispness is

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580.—Why is the smell and savor of plants diminished in the shade? **581.**—What is said of celery? **582.**—What mode of treating it is proposed by Caroline? **583.**—What objection is there to it? **584.**—How are lettuces made to grow white and tender? **585.**—What does Caroline say of the growth of cabbage? **586.**—And what of endive? **587.**—What would take place with the crispness, had not the plant been sheltered from the light? **588.**—How are the different parts affected by the operation of cooking?

very agreeable to the palate in lettuces and endive when eaten raw, and it becomes perfectly soft by cooking; whilst those parts of a vegetable in which the woody fibre begins to be developed, by the deposition of carbon, after cooking remain tough and stringy. You must have noticed this difference in every dish of cardoons and of celery which is served at table: those parts from which the light has been completely excluded are quite soft and tender, whilst those ribs which have been partially exposed to it, are more indurated and fibrous.

It was supposed by the ancients, and, indeed, taught by their great naturalist, Aristotle, that the verdure of plants was developed by the atmosphere, and that it was the exclusion of air which prevented the roots from assuming that color.

Emily. What would be the consequence of depriving a plant entirely of light?

Mrs. B. The leaves would become dropsical and fall off: fresh leaves would, indeed, sprout; but these, having no power to decompose carbonic acid, would be completely etiolated. Deprived of carbon, and in a great measure of the earthy matter deposited by evaporation, the new shoots would be soft and feeble, but considerably elongated by the absorption of fluid which they have not power to throw off.

Mr. Bonnet of Geneva cultivated some peas in a cellar totally dark, and they were completely etiolated.

Emily. Pray, can you tell me why plants turn their leaves and flowers, and even stretch out their branches towards that side on which the light predominates?

Mrs. B. Some have imagined that this preference resulted from a sort of instinct; others have gone so far as to discover in it an indication of sensibility.

Emily. I begin to take such an interest in plants, since you have made me better acquainted with them, Mrs. B., that I should be delighted to find they were raised something above the mere passive mechanical beings in which Nature carries on her chemical and physical process without their interference.

Mrs. B. In all organised beings life plays so consid-

589.—What was supposed by Aristotle? **590.**—If plants were entirely deprived of light what would be the consequence? **591.**—What experiment was made by Bonnet? **592.**—Why do flowers and leaves turn towards the light? **593.**—What does Mrs. B. say of instinct and sensibility as belonging to vegetable life?

erable a part, as effectually to distinguish them from mere brute matter ; but, in regard to the instinct and sensibility of the vegetable creation, I fear we must abandon the subject to poets, who have often treated it with much beauty.

The inclination of plants towards the light, we sober minded botanists account for in a far less romantic manner.

I must relate to you an experiment made by Mr. Texier, which shows that plants, far from being endowed with feeling, are mechanically compelled, by their kind parent Nature, to turn towards that quarter which is most conducive to their well-being. Mr. Texier placed a plant in a dark cellar, where it was supplied by openings on the one side with light, and on the other with air ; and the plant was left at liberty to give the preference to either. In a short time the point was decided : both leaves and branches extended themselves towards the light. This partiality may, perhaps, be thus explained. Those parts of a plant most exposed to the light becoming harder and less susceptible of elongation than the parts more in the shade, the two sides being unequal, the one is obliged to yield to the other; the soft, yielding, elongated side to that which is harder and more contracted. If one side of a branch is more elongated it will take a curved form, as may be seen in the figure (Plate IV. fig. 5. ;) where the dark line represents the accumulation of carbon and contraction of growth, and the fine line, the softer texture and greater elongation; and thus you see that the plant mechanically assumes a position in which it may receive the greatest benefit from an element so essential to its welfare.

Caroline. This is extremely curious; and it accounts for the tendency of plants towards the light in a manner so simple and clear, that, mechanical as it is I cannot doubt its correctness.

Mrs. B. It has been suggested, that advantage might be taken of this natural mode of curving wood for the construction of ships, the ribs of which are bent by artificial means. Let us now proceed to examine the effect of temperature on plants.

Heat excites and accelerates the circulation of the jui-

594.—What experiment was made by Texier? 595.—What was the result? 596.—How was this result explained? 597.—How is it illustrated by fig. 5, Plate IV.? 598.—What advantage does Mrs. B. think might be taken of this in the growing of timber? 599.—What effect does heat have on the circulation of the juices of plants?

ces of plants, as it does those of the animal frame; but this effect varies in different species of plants, and even in different individuals of the same kind. It is the accelerated motion of the sap, during the warmth of spring, which determines the period of the budding of the plant; and, as the temperature of the season increases, produces a greater absorption by the roots, of evaporation by the leaves, developes the blossom, and, finally, ripens the fruit.

The action of heat in these operations is not merely mechanical, but produces effects on the living plant very analogous to those which it does on animals.

When, on the contrary, the temperature of the soil is as low as the freezing point, the spongioles finding no fluid to imbibe, the plant, deprived of sustenance, languishes; and, should this privation continue any length of time, it perishes of famine.

Emily. And if the heat be so intense as to evaporate all the water of the soil, the plant will be equally deprived of nourishment.

Mrs. B. The effect is similar, though produced by so opposite a cause. The plant will in the last case, however, perish sooner; for, besides being deprived of sustenance, it will evaporate its own moisture. But let us first inquire into the effects of a low temperature on plants. Water may freeze within a plant, but it is less liable to congelation after, than before being absorbed by the roots; not only because it is better sheltered from the external cold, but because the motion of the sap is unfavorable to congelation.

If the stem of a tree freezes, the elasticity of the vessels requisite for the circulation of the juices is destroyed, and the plant perishes both from cold and hunger. But if merely the leaves and buds be frozen, they alone are destroyed; and the sap, which the stem continues to transmit to the branches, enables them to sprout out new buds and fresh leaves.

Caroline. So, a man would still live, were his nose or

600.—What determines the period of budding? 601.—To what is the action of heat in these operations analogous? 602.—When the temperature of the soil is as low as freezing point, what is the consequence? 603.—When the heat is so intense as to evaporate all the water of the soil, what will be the consequence? 604.—Why is water within the plant less liable to congelation than before it was absorbed? 605.—When plants freeze what is the consequence.

fingers frozen. The analogy, however, will go no further, for he has not the advantage of sprouting out new ones.

And on the other hand, what degree of heat will plants support?

Mrs. B. It varies extremely, depending on a variety of circumstances. The *Vitex agnus castus* has been known to strike root in water at the temperature of 170° Fahrenheit.

When one of the hothouses of the Botanical Garden of Paris was burnt, all the plants within it perished excepting the flax of New Zealand, which resisted the temperature of a general conflagration that consumed even its leaves.

The temperature of some few plants experiences an elevation at the moment of flowering: that of the *Arum maculatum* rises from fourteen to twenty one degrees, when its blossom expands between three and five o'clock.

Emily. Do plants, like unorganized bodies, partake of the temperature of the atmosphere in which they grow? I should have imagined that they must be warmer; for, since some portion of the water which a plant absorbs remains incorporated in it under a solid form, in changing its state from fluid to solid, it must give out its latent heat, which would raise the temperature of the plant.

Caroline. But you forget, Emily, that two thirds of the water which the plant absorbs is evaporated, and, by changing its form from liquid to vapor, cold must be produced. Now, as the quantity which assumes the form of vapor is much greater than that which becomes solidified, the temperature of the plant should ultimately be lowered beneath that of the atmosphere in which it lives.

Mrs. B. Each of your opinions have been sanctioned by different naturalists; but, however exact these calculations may be in the laboratory, they can give us but very little insight into the chemistry of vegetation, where that mysterious principle *life* performs so essential a part.

Emily. Yet, is it not easy to ascertain by the thermometer whether plants differ in temperature from the atmosphere?

606.—At what temperature was the *Vitex agnus castus* known to strike root? 607.—What is mentioned of the flax of New Zealand? 608.—What fact is stated of the Arum maculatum? 609.—What reason does Emily give for supposing that the temperature of plants will be higher than that of the atmosphere in which they grow? 610.—What reason is given by Caroline for a contrary opinion? 611.—What is the reply of Mrs. B. to both?

Mrs. B. It appears by that test, that the trunk of a tree is colder in summer, and warmer in winter, than the air by which it is surrounded; and the larger the stem, the more this difference is manifest. But the reason of this is very simple: the roots draw their nourishment from a depth of soil, well sheltered from both extremes of heat and of cold: the water they absorb remains throughout the year of a moderate temperature; and the stem, which serves as a channel to transmit this water to the branches, naturally acquires the temperature of the fluid it conveys. The sap thus tends to cool and refresh the plant during the heat of summer, and to cherish and preserve it from being injured by the severity of winter; but should this severity be so intense or of such long duration as to penetrate into the deep recesses of the soil, whence the sap is drawn, the temperature of the tree will gradually descend to that of the atmosphere.

Caroline. The stem has still another defence from the cold, in the several layers of bark; which we may, I suppose, consider as so many warm coats to preserve the internal temperature of the tree?

Mrs. B. Certainly. The bark is a bad conductor of heat, and, like flannel-clothing, serves equally to keep in warmth during winter, and to exclude heat in the summer.

Notwithstanding all these precautions, which Nature has so wisely taken to preserve the equable temperature of plants, the water within the stem is sometimes frozen; and as water when converted into ice occupies a larger space than in its fluid state, it bursts the vessels in which it is contained, and injures, if it does not destroy, the texture of the plant.

Emily. But should this occur after a dry season, so that the cells which contain the water be not filled, there will be room for its expansion in freezing.

Mrs. B. True; freezing may then take place without considerable injury to the plant: it is only when the

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612.—By the thermometer how does the temperature of a tree compare with the air around it? 613.—What is the reason for such a result? 614.—How will this result be varied provided the severity of winter be of long continuance? 615.—What effect has the bark on the temperature of the tree? 616.—But what will be the effect, if water in the stem of plants be converted into ice? 617.—Under what circumstances will the freezing of plants be attended with the least evil?

parts become disorganised, from the fracture of the vessels of the cellular system, that the plant itself is said to be frozen. The more water, therefore, plants contain, the more liable they are to injury from frost; and, accordingly, we find that aqueous plants are those, most easily frozen. What parts of a plant should you suppose most liable to be attacked by the frost?

Caroline. Those which contain most water: the leaves, where that liquid is conveyed to be evaporated; and the buds, where, during spring, the sap is brought in such abundance for their nourishment. Besides, the leaves and the buds are most exposed to the air, while the stem and branches are well defended from its inclemency by their warm clothing, the bark.

Mrs. B. You have judged rightly. If the frost be so inveterate as to attack the stem, it is the alburnum, as being the most moist and tender, which first suffers; afterwards the liber, the internal coating of bark. If this freezes, death must ensue, as the vessels which convey the cambium are lodged in this coating. The external layer of bark is the driest of any part of the plant, being constantly subjected to the inclemencies of the season. It is often injured, and in the lapse of time destroyed, and peels off; but it is never frozen.

Emily. Plants must be more liable to freeze in the spring than in the autumn, at an equal temperature, because they contain more water in the former than in the latter season.

Mrs. B. True. In autumn the absorption of sap diminishes, in the spring it increases, both in quantity and celerity of motion, in order to provide for the budding of the plant; and if in this season a frost should prevail, there is great danger of the plant falling a sacrifice to it.

Plants of different species vary much in their power of resisting cold. Oaks do not freeze at 56° below the freezing point of Fahrenheit; beech will support 79°, an intensity of cold which congeals mercury. Mr. De Can-

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618.—What plants are most easily frozen? 619.—Why should the leaves and buds of plants freeze sooner than the stems? 620.—What parts of the wood will freeze first and which last. 621.—Why will not the bark freeze? 622.—Why are plants more liable to freeze in Spring than in Autumn at an equal temperature? 623.—What are instances of different trees freezing at different temperatures?

dolle found snow-drops in blossom on Mount Salève beneath the ice; and Captain Parry, in his Polar expeditions, discovered many plants, in full leaf and ready to blossom, encased in ice.

It is remarkable that plants, which are the greatest sufferers by extreme cold, are at the same time most liable to injury from intense heat. But this apparent inconsistency admits of an easy solution. We have observed that aqueous plants are easily frozen; they also evaporate abundantly; therefore, when exposed to extreme temperature, whether of heat or cold, they will be either frozen or dried up.

Plants which secrete a viscous juice do not easily freeze: the tenacity of this thick, sticky fluid prevents, or at least impedes, that arrangement among the particles which is necessary to produce congelation. Freezing, you know, is a species of crystallisation; and it is requisite that each particle of liquid should be free to range itself in that order which is essential to the formation of such regular bodies as crystals.

Caroline. The rising sap then must freeze more easily than the descending sap or cambium, as the latter is thicker and more viscous.

Mrs. B. Yes; and there is also another reason why the sap is more liable to freeze than the cambium: the former moves with greater celerity, so that its particles more easily place themselves in the order of crystallisation.

Emily. Might not recourse be had to the expedient of stripping the plant of its leaves, in order to diminish the velocity of the rising sap, when in danger of freezing? For by depriving a plant of the organs of evaporation you lessen its power of absorption.

Caroline. But, by preventing the elaboration of the sap in the leaves, you hinder it from acquiring that consistence which enables it to resist congelation; you render

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624.—What is stated by Candolle and Parry in illustration of this subject? 625.—Why are plants, most liable to suffer from the cold, most liable to suffer from intense heat? 626.—Why do plants which secrete a viscous juice not easily freeze? 627.—What is freezing said to be, and what is requisite that it may take place? 628.—What are the two reasons why the rising sap freezes more readily than cambium? 629.—Why does Caroline say the stripping plants of their leaves would not lessen their liability to freeze?

the plant dropsical by the accumulation of water; and aqueous plants, Mrs. B. has told us, are most liable to freeze.

Mrs. B. Emily's expedient has been tried, but not without danger of the consequences you deduce from it.

Fleshy fruits, such as oranges, apples, and pears, requiring a great quantity of sap to supply sustenance, occasion a great absorption by the roots. These plants are, consequently, particularly liable to injury from frost; and, when thus endangered, it is a useful precaution to gather the fruit, in order to secure the tree. In the south of France, the oranges are gathered on the first appearance of a frost; and should this operation not be completed before the frost sets in, it frequently occurs that the side of the tree on which the fruit remains is attacked by the frost, whilst that on which it has been gathered escapes uninjured.

Caroline. Then, in cases of such urgency, they should begin by gathering the fruit on the north side of the tree, as being most exposed to the cold.

Emily. Some fruits, like the peach, are coated with a soft down; which, I suppose, answers the purpose of warm clothing?

Mrs. B. Yes; it is perhaps, even a better preservative from the cold than the coatings of the epidermis. This soft down encloses and confines the particles of air on the surface of the fruit on which it grows. Air, you may recollect, is a very bad conductor of heat, and especially air in a tranquil state; that which is imprisoned by the down affords, therefore, the most useful shelter to the plant.

Emily. I have often experienced the advantage of a precaution of this nature, by holding up my fur-tippet, before my mouth when encountering a sharp frosty wind; the air, held captive by these slender threads, reposes tranquilly in its downy prison, and becomes mild and genial to breathe.

Mrs. B. You must observe, also, that, during its captivity, it is tempered by the warmth of the breath you expire, before being inhaled by the lungs; so that, in fact, you breathe a tepid, instead of a frosty air.

630.—Why do oranges, apples and pears, readily freeze? 631.—What singular occurrence sometimes happens to orange trees in the south of France? 632.—Why is the down upon peaches a good preservative against cold? 633.—To what does Emily compare this? 634.—How does the air thus held become tempered before it is breathed?

A layer of air is also retained captive between the epidermis and the bark, which is, perhaps, a still better preservative to the plant than the bark itself: it is a delicate under-garment, which the stem wears beneath its more cumbrous clothing of epidermis.

Caroline. The epidermis was itself, I thought, a delicate covering to the internal layers of bark.

Mrs. B. That depends upon the nature of the plant, and the part to which it belongs. The epidermis of the leaves and buds is delicate, but that of the stem and branches of a venerable oak is of a very different description: the bark in general which covers the trunk consists almost wholly of carbon; which, being a very bad conductor of heat, answers the double purpose of confining the internal heat in winter, and excluding the external heat in summer.

The epidermis itself is sometimes single, sometimes double or triple, but more commonly consists of a number of layers. So many as one hundred and fifty have been counted in the epidermis of a tropical plant; and so great a number still remained that the calculation was abandoned from the difficulty of completing it.

At our next interview we shall examine, how far plants will admit of being naturalised to a climate differing in temperature from that in which they are indigenous; and what are the precautions necessary to be taken in transplanting them to a foreign country.

CONVERSATION VIII.

ON THE NATURALISATION OF PLANTS.

Mrs. B. In estimating the effect of diversity of climate on plants, the point most important to be considered is the difference of temperature. The nature of the soil, the air, water, and light, are circumstances comparatively trifling, compared with the abundance or deficiency of heat.

635.—What is said of the air held between the bark and the epidermis? 636.—What is said of the nature of the epidermis? 637.—What is said of the nature of bark, considered as capable of resisting the cold and heat? 638.—Of how many layers does the epidermis consist? 639.—In estimating the effect of diversity of climate on plants what point is of the most importance to be considered?

Emily. I should have imagined that the quality of the soil and the quantity of water would have been of still greater consequence than the temperature.

Mrs. B. When we wish to naturalise a foreign plant, art may do much in rendering the soil analogous to that in which it originally grew, in affording it a due quantity of water, in sheltering it from, or exposing it to the light. The nature of the air varies very little in any latitude, but its temperature most remarkably; and over this art has little or no control.

Caroline. You forget our hothouses, Mrs. B., where we produce whatever temperature we choose.

Mrs. B. True; but the plant cultivated, or I should rather say forced, in such an artificial atmosphere remains a foreigner, and does not become a naturalised subject of the vegetable realm.

If you compare the mean temperatures of different countries, you will be surprised to find how much more nearly they approximate to equality than you would at first imagine. For instance, those of England and of Switzerland do not vary above two or three degrees; yet they frequently will not admit of the cultivation of the same plants. In Switzerland it is hotter in summer than in England, owing to the latitude; whilst its local elevation, and the vicinity of mountains covered with snow, renders it colder in winter. The more equable temperature of England, throughout the year, enables every species of laurel, and even Rhododendrons, to support the winter with impunity. In Switzerland the common laurel, if it escape being frozen, suffers so much as greatly to injure its vigor and its beauty: the contrast of a strong vegetation in summer, suddenly checked by the severity of winter, ill accords with its nature. The laurustinus and the Portugal laurel are unknown in Switzerland, except as greenhouse plants; whilst, on the other hand, the fruit of the vine, which we can but imperfectly ripen in England, in Switzerland affords a luxuriant vintage.

640.—What is it said that art may do for the soil in reference to foreign plants? 641.—What does Mrs. B. say of hothouse plants? 642.—With what does she say one will be surprised? 643.—What comparison is made between the temperature of England and Switzerland? 644.—What is said of the growth of laurel and Rhododendrons, in these two countries? 645.—And of the lauristinus, the Portugal laurel, and the vine?

Emily. I am often inclined to envy them their oleanders and pomegranates, which blossom so beautifully in the open air, and require the shelter of a greenhouse only in winter; while we produce very inferior plants of the same description even in our hothouses.

Caroline. Yet the temperature of Switzerland must be lower than its latitude would indicate, owing to its elevated situation; for being nearly in the centre of Europe, whence almost all the great rivers have their source and flow into the sea, it must be the spot most raised above that level.

Mrs. B. Certainly. In estimating the temperature of a climate, the prevalence of hot or cold winds, such as the *sirocco* in the south of Italy, the *mistral* in the south of France, and the *bise* in the valleys of Switzerland, should be taken into consideration, as well as the locality of the spot; which, independently of its degree of elevation above the level of the sea, is liable to be affected by a variety of circumstances. One of these, which, however remarkable, naturalists have not hitherto been able satisfactorily to account for, is, that in countries of similar elevation and latitude the temperature is always higher in those situated on the western than on the eastern side of a continent. It is warmer, for instance, at Nantes, on the western shore of France, than at Quebec, on the eastern shore of America, both being very nearly of the same latitude. At Quebec, snow-shoes and sledges are in general use during several months of winter, and booths are built upon the frozen river St. Lawrence; whilst at Nantes frost and snow are little known, and of short duration.

Emily. But how far can plants accustom themselves to a climate and temperature which is not natural to them?

Mrs. B. It varies extremely, according to the nature of the plant. The horse-chesnut, which is so well naturalised to our northern climates, that it braves even the inclement skies of Sweden, was originally brought from

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646.—Why does Caroline say the temperature of Switzerland must be lower than its latitude would indicate? 647.—What winds are named that should be considered in estimating the temperature of a place? 648.—For one circumstance named naturalists have been unable to account—what is it? 649.—What comparison is made between Nantes and Quebec? 650.—What is said of the horse-chesnut?

India; where it grew, it is true, on mountains, but of no very considerable elevation. Some plants succeed only partially on being transplanted to a foreign climate. Thus the artificial grasses, such as clover and cinquefoil, thrive very well as grasses: they are cut down when in blossom, the heat of summer being seldom sufficient to ripen their seed, we are under the necessity of importing it from warmer climates, in order to renew them.

Emily. I thought that the artificial grasses were cut down at that earlier period of their growth, as being then most tender, and best suited for the nourishment of cattle.

Mrs. B. That is true: but were we able to ripen the seed, we should cultivate a portion for that purpose, instead of annually renewing it from foreign parts.

Caroline. Why have these grasses obtained the name of artificial?

Mrs. B. Because they require continued cultivation from seed. They are not perennial, but must be constantly resown; whilst most of the grasses of our pastures and meadows spread by the root.

There are many plants which will not admit of transplanting to a colder climate: thus the orange and the olive have made no progress northward since the time of the Romans, but are still confined to the same limits.

Caroline. The orange-tree bears our climate under shelter of a greenhouse extremely well.

Mrs. B. There are few plants which cannot be cultivated with some degree of success, by the artificial temperature of a greenhouse or a hothouse; but I am speaking of their being naturalised to a climate, so as to admit of being raised in the open air.

When you make the experiment of introducing a new plant from a warmer climate, you must treat it with great care, and endeavor, by gentle gradations, to wean it from its native country, and accustom it to our more inclement skies. You should begin by placing it in a hothouse; the following year you may try the greenhouse; and, if it does not appear to suffer from this change, you may

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651.—And of artificial grasses? 652.—Why do some grasses obtain the name of artificial? 653.—What plants will not admit of transplanting? 654.—Are there any plants which cannot be well cultivated by artificial temperature? 655.—When a new plant is to be introduced from a warmer climate, what should be the mode of treatment?

finally expose it to the open air. While the plant undergoes this species of education, you have the advantage of studying its habits, the nature of the soil most favorable to its growth, the quantity of water it requires, the degree of light to which it should be exposed, the wind which it will support, and a number of minute circumstances, which will indicate the situation and treatment most congenial to it, on transplanting it into the open air. This knowledge of the habits of plants is highly essential to their success, in becoming naturalised to a foreign climate.

Emily. Undoubtedly. If it be found that they require much moisture, it will be expedient to plant them in hollows rather than on rising ground. When the plant is tender and delicate, so that light, heat, and shelter become essential to its preservation, you must select a southern aspect, that it may derive every possible advantage from the sun, and be sheltered from the north wind.

Mrs. B. You must also pay attention to plant it rather deep in the soil, in order that its roots may be supplied with water of a moderate temperature, and that the neck or vital part of the plant be sheltered from the inclemency of the weather, by being well covered with earth. Then it should be transplanted in the spring, in order that it may be gradually accustomed to a diminution of temperature, instead of being suddenly exposed to the severity of winter. Besides, if planted in the spring, it will be hardened against the following winter by the deposition of carbon during the summer. It is desirable, also, to plant it in a rich vegetable soil, in order to afford it plenty of nourishment.

Caroline. In Switzerland, they plant rhododendrons and kalmias in pots of remarkably black earth.

Mrs. B. The bog-earth or peat-earth of England, though less rich, is of the same nature, consisting chiefly of vegetable remains. There are whole districts in Belgium of this nutritive vegetable soil, which is converted into nursery gardens for raising kalmias, rhododendrons, and other plants of this description, where they grow and

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656.—What may be learnt when it is undergoing this species of education? 657.—Why should a southern aspect be selected for it? 658.—Why must it be planted deep? 659.—Why should it be transplanted in Spring? 660.—In Switzerland how are rhododendrons and kalmias cultivated? 661.—What is said of the cultivation of them in Belgium?

prosper in the open air. In England the rhododendrons succeed perfectly well in our gardens, though the soil is less rich in carbon than the bog-earth of Belgium; but the moisture of our climate is particularly favorable to that, as well as to every species of laurel, and to evergreen plants in general.

In transplanting from a colder climate, very few precautions are required: an elevated situation is desirable, and a sufficiency of water to provide for the more abundant evaporation to which the plant is subjected.

Plants brought from a warmer climate should be watered but moderately, because the power of evaporation is checked by the diminution of temperature. This is particularly to be observed in autumn, when the cold weather first sets in.

Emily. And in that season, the direction, I should suppose, would be applicable to plants of every description, none of them being capable of evaporating so much during winter as summer, especially when deprived of their organs of evaporation—the leaves.

Mrs. B. True; but not equally applicable to those which preserve them. Such greenhouse plants, for instance, as geraniums and orange-trees, which retain their organs of evaporation throughout the winter, though that function is more imperfectly performed during this season, will admit of being watered with less parsimony than others.

Emily. Do you approve of sheltering delicate plants, by covering them with straw or matting during the winter?

Mrs. B. If the spot in which they grow be elevated, and the soil dry, it may be done with advantage; but in low damp situations such a precaution might occasion the plant to rot, particularly evergreens, as the covering would prevent the evaporation of any superabundant moisture by the leaves. In such cases, it is better to leave the plant exposed, taking care, only, to shake off the snow which, if melted by the sun during the day, runs down the stem and branches, and insinuates itself into any little crevice it may chance to find in its passage, or

662.—What is said of transplanting from a colder climate? **663.**—How are plants brought from warmer climates to be watered? **664.**—What is said of the watering of geraniums and orange trees? **665.**—And of sheltering delicate situations? **666.**—In low damp situations what is better?

is absorbed by the buds and tender parts of the plant as it trickles over them. Then at night, if this water freezes it injures, if it does not destroy, the texture of the parts in which it is lodged.

Caroline. It must surely be desirable to plant such trees against a wall in a southern aspect, even under the inconveniences to which such a state of confinement subjects them.

Mrs. B. It is attended with several advantages, which, in the initiation of tropical plants to our climate, often more than compensate the injury resulting from confinement. A southern wall not only affords shelter from the north wind, but becomes a source of heat, by the transmission of the sun's rays to the plant.

Emily. The white walls of France and Switzerland must reflect a great deal of heat; but I should not have supposed that our brown brick English walls would have produced much effect, for they must absorb more heat than they reflect.

Mrs. B. The rays, whether reflected or absorbed by the wall, are alike beneficial to the tree planted against it; for no sooner does the temperature of the wall become elevated by the absorption of heat than it radiates this heat, which is thus transmitted to the tree in contact with it.

The injurious effects of the captivity of the branches must, however, be taken into consideration; for, besides the salubrious exercise which free access of air affords to a plant, this agitation augments the power of evaporation —a power which it is very desirable to encourage, as it is necessarily diminished in a climate of a lower temperature than that in which the plant was placed by Nature, especially in England, where the atmosphere is impregnated with moisture. It is owing to this circumscribed power of evaporation that wall-trees are less hard in their texture, and contain less carbon, than those which grow freely.

667.—What will be the effect of planting trees upon the south side of a wall? 668.—What comparison does Emily make between the walls of France and Switzerland and those of England? 669.—What is the reply of Mrs. B.? 670.—What is said of the effect of confinement to trees against a wall? 671.—Why are such trees less hard in their texture?

Emily. Let me endeavor to recapitulate the several circumstances to be attended to in transplanting from a warm to a cold climate. In the first place you must make the plant pass through the various gradations of the hot-house and green house, previous to exposing it to the open air; you must then plant it in the spring, deep in a richly-carbonised soil, and cover up the vital point of junction between the stem and the roots. It must be placed in a southern aspect, or against a south wall, watered with great moderation: the fruit must be gathered before the frost sets in; and the plant may be covered with matting in winter, if situated in an elevated spot in a dry soil.

Mrs. B. I believe you have enumerated all the directions I have to give you on this point.

I shall add a few remarks on greenhouses and hot-houses, as necessary to the cultivation of such plants as cannot be familiarised to our climate. They should both be situated, as far as is practicable, in a southern aspect.

Emily. But when this is not attainable, to which do you give the preference, a south-east or south-west aspect?

Mrs. B. The first has the advantage of affording relief earliest to a plant which has suffered from the cold during the night; the latter that of sheltering it from the severe east wind: upon the whole I should be inclined to choose the latter.

Verticle windows have the advantage of not retaining the snow, the disadvantage of admitting less light and heat; and in England, where we are not much troubled with snow, and require all the heat we can obtain in winter, the inclined windows are certainly preferable and are almost universally adopted; whilst on the Continent, where less heat is required, vertical windows are more common.

In southern climates, the house must not be built deep, in order to admit the sun's rays to every part; in northern climes, the sun's rays falling more obliquely, a greater depth of building is admissible: the roof should project

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672.—What is the recapitulation of the several circumstances to be attended to in transplanting from a warm to a cold climate? **673.**—What is the advantage of a southeast and a southwest aspect for plants? **674.**—What is said of different windows for hot houses? **675.**—And of the depth of hot houses?

and be coved, so as to collect the rays of the sun and reflect them into the house.

In order to protect hothouses and greenhouses from humidity, they must be warmed and aired at the same time: the heat both dissolves the moisture and prevents the plants from suffering from the external air while the windows are open; and the current of air carries off any moisture which is not dissolved.

The finest hothouses are in Russia, where the wealth of the higher classes enables them to indulge in luxuries. In their cold climate, hothouses and greenhouses are considered as necessary articles of comfort. In England, Mr. Loddiges' establishment at Hackney exhibits the most perfect model of hot and greenhouses: they are warmed by vapor, and when necessary, watered by the tepid water into which the steam is condensed. The building is one thousand four hundred feet in length, and divided into compartments, each of a different temperature.

Emily. What effect has the tan which is used in hothouses?

Mrs. B. It produces heat, by undergoing a degree of fermentation; but it also generates humidity, and heat and humidity favor the propagation of fungi and of worms; and should the roots of the plant grow below the pot, and penetrate into the tan, its contact is injurious.

The smaller and lower the house, the more favorable it is to young and delicate plants: the heat always rises, so that in large and elevated houses the small plants of the lower range are situated in an atmosphere of cold air It is for this reason that slips of greenhouse plants are generally placed in beds covered with glass in order to strike root, where they receive as much heat in as small a space as possible.

CONVERSATION IX.

ON THE ACTION OF THE ATMOSPHERE ON VEGETABLES

Mrs. B. This morning we shall turn our attention to the manner in which the atmosphere affects the vegetable

676.—And of warming and airing them? 677.—Where are the best hothouses? 678.—What description is given of the one mentioned in England? 679.—What is said of the use of tan? 680.—Why are slips of greenhouse plants generally placed in beds covered with glass?

world. It acts on plants in two ways: both mechanically and chemically.

Caroline. But in a very different manner from what it does on animals: we only breathe the air; plants may in some measure be said to feed on it, since they absorb carbon from the atmosphere.

Emily. They also absorb oxygen from that source; but it is true they restore it with ample interest, thus purifying the air we animals have contaminated by our breath. But since carbon is such a favorite food of plants, I should like to try the experiment of enclosing a weakly, debilitated plant in an atmosphere of carbonic acid, to see whether the abundance of such nourishment would not restore its vigor.

Mrs. B. The quality of the food would be excellent; but nothing is good when administered in excess. Such an experiment would resemble the attempt made to restore pulmonary patients to health by giving them pure oxygen gas to respire: at first it seemed to be attended with beneficial effects; but the deleterious consequences occasioned by too great excitement of the lungs, was soon discovered, and the experiment abandoned. We cannot be too cautious in our proceedings when we venture to deviate from the paths which nature has pointed out.

The chemical action of the atmosphere on plants we have already so fully investigated in our preceding Conversations, that, although it be no less applicable to our present subject, it would be but repetition to return to it. I have not, however, yet mentioned, that the electricity of the atmosphere appears to affect plants; it is at least an undoubted fact that vegetation is accelerated during a storm.

Emily. May not that arise from the agitation produced by the wind? Branches being tossed to and fro, must greatly increase the velocity of the sap, and the deposition of its nutritive particles; the evaporation from the leaves must also be considerably augmented by the wind blowing them about, and carrying off the vapor the in-

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681.—What is the subject of the ninth Conversation? 682.—What experiment does Emily propose to try? 683.—What does Mrs. B. say would be the result? 684.—What takes place with vegetation during a storm? 685.—How does Emily account for this?

stant it is formed. Such a state of stimulus might be followed by a debilitating re-action, as is the case with us, after excessive exercise; but, while it lasts, it must produce a very great increase of action throughout the frame.

Mrs. B. That may possibly be a concurring cause of the phenomenon, but it is not sufficient to account wholly for it. Mr. De Candolle mentions the remarkable growth of the branch of a vine during a storm, of no less than an inch and a quarter in the course of an hour and a half; now the tree grew against a wall, so as to be little accessible to the wind.

The quantity of water contained in the atmosphere is a point of great importance to plants. Water, you may recollect, exists in the atmosphere in two different states: in the one it is so completely dissolved, that the air feels perfectly dry to us, and affords no moisture to the vegetable part of the creation. It is heat which enables the air to perform this solution; therefore the higher its temperature the more water it can dissolve.

Caroline. Then the atmosphere in the torrid zone, though driest, contains most water:—that appears very paradoxical.

Mrs. B. It is nevertheless true. Whenever the air cools, its power of retaining water in solution diminishes.

Caroline. This must happen, then, not only when the weather changes from hot to cold, but every evening after sunset.

Mrs. B. Accordingly, we continually see misty vapors floating in the atmosphere in the evening, and the ground more or less covered with dew: all this is water precipitated by the diminution of temperature of the air. In the morning, when the sun has sufficiently warmed the atmosphere to enable it to dissolve these fogs and vapors, they disappear.

The other state in which water exists in the atmosphere is that of a fine subtle vapor, diminishing its clearness, and giving us the sensation of humidity.

Emily. The latter state, I should suppose, would be

686.—What does Candolle say of this subject? **687.**—And of the water contained in the atmosphere? **688.**—In what region does the atmosphere contain most water? **689.**—How is the dew at evening produced? **690.**—What results to the dew from the warming of the atmosphere in the morning? **691.**—In what other state does water exist in the atmosphere?

the most advantageous to vegetation, for plants almost always require water.

Mrs. B. It is to the dampness of our climate that we owe the fine grass of our beautiful meadows and lawns, for which England is so celebrated, and which are in vain attempted to be imitated on the Continent; unless it be in some very elevated spots, where the grass is nurtured by the mountain mists. It is to this cause, also, that we are indebted for the prosperity of our laurels, and a variety of evergreens; yet a damp climate has its attendant disadvantages, even as regards the vegetable creation. Fogs and vapor diminish the quantity of light, and, consequently, the numerous benefits resulting from it, such as absorption, evaporation, deposition of carbon, and developement of color. In this point of view, therefore, a very moist climate injures the beauty and vigor of vegetation.

Trees growing on mountains, where they are much exposed to vapor, are very liable to suffer from what is commonly called a white frost. The clouds and mists, so prevalent in those elevated regions, bedew their branches with a light coating of watery vapor, which easily freezes during the night; the morning mist attaches itself to this thin layer of ice, and shoots into minute frosty crystals, called a white frost.

Caroline. The white frost, which we so commonly see on the grass, is formed, I suppose, by the freezing of the dew.

Mrs. B. Yes; and it is, you know, so light as to disappear soon after the sun has risen above the horizon.

Moisture is particularly inimical to blossoms: if it comes in contact with the anthers, it destroys them, and the flower bears no seed. This disease often affects the vine, and not unfrequently corn, to the great injury of the vintage and the cornharvest. Moisture is prejudicial, also, by giving rise to the propagation of fungi, of parasitical plants, and even of worms.

There are some plants to which the moisture of seabreezes is so essential, that they cannot be cultivated in any other situation than on the shores of the ocean.

692.—What effect on vegetation does the dampness of climate produce? 693.—What unfavorable effects on vegetation are caused by fogs and vapors? 694.—What is said of trees growing on mountains? 695.—How is white frost produced? 696.—How does moisture effect blossoms? 697.—What is said of the effects on vegetation from sea breezes?

Emily. These plants, doubtless, require sea-salt; and yet the vapor which exhales from the sea is perfectly sweet, the clouds which they form are never impregnated with salt; how, therefore, can plants obtain it?

Mrs. B. Not from the vapor which rises from the sea, but from minute drops of salt water, which are projected into the air by the agitation of the waves, and carried by the wind to the shores. Salsola kali, or kelpwort, is a plant of this description: if grown in an inland situation it contains not a particle of soda, the alkali from which it derives its value; for this can be obtained only from *muriate of soda*, or sea-salt. During the late war between France and Spain, the French, being greatly distressed for soda, which they had imported chiefly from Spain, attempted to cultivate kelpwort on the hills bordering the sea-shore in the south of France. When planted on the southern side of the hill, sloping towards the sea, the crop succeeded perfectly; and, the price of soda having risen very high, one single harvest repaid the price of the land on which it was raised. But when planted on the north side, where it was not exposed to the briny particles, it failed completely, and the plant contained no other alkali than potash.

Emily. This explanation solves a difficulty which had often perplexed me. The sea-air is, you know, much recommended to invalids as a tonic; and the fogs and damp mists, so prevalent on the sea-shore, do not appear to be attended with the debilitating effects produced by inland fogs: this must be doubtless owing to the tonic qualities of the briny particles with which the sea-air is impregnated.

Caroline. It is true, one can seldom walk out on the sea-shore without one's dress suffering from humidity; and the salt with which this humidity is loaded is often so strong as to be sensible to the taste. But this prevails only within some few hundred yards of the shore: on rising upon the downs it is no longer perceptible; and yet it is the air of these downs which is reckoned so particularly invigorating.

698.—How are these effects produced? 699.—What is said of kelpwort? 700.—Of its growth in France what is said? 701.—What difficulty does Emily say is solved by the account given of the cultivation of kelpwort?

Mrs. B. The saline particles are too ponderous to be carried to such a height; but there you experience the salubrious effect of mountain air. The salt is not requisite to render it tonic: it is only when you descend on the opposite side into the inland country, that you perceive the want of those invigorating qualities for which the sea-air is so celebrated.

It is remarkable that kelpwort exudes a portion of the alkali which it receives from the atmosphere into the ground, the soil on which it has been cultivated being found to contain more than when such a crop has not been raised upon it. This is owing, probably, to the quantity it absorbs, being more than the plant requires.

Emily. This, then, affords an exception to the general nature of the exudation of plants by the roots, as it must constitute appropriate nourishment for other plants of the same species.

Caroline. And is not the air also useful as a vehicle to transport small seeds from one country to another?

Mrs. B. Yes; there is scarcely any resemblance between the plants of Europe and of America, excepting in *Cryptogamous* plants, because the seeds of lichens, of mosses, and of fungi, of which this family is composed, are so small that they float in the air, and are transported by the wind from one continent to the other.

The wind also performs the part of a careful sower, dispersing the seeds which fall from the plant with regularity over the soil.

Caroline. I wish it would distinguish between weeds and flowers, and confine itself to the dispersion of useful seeds; but it seems to delight in the propagation of weeds: if any thistles or groundsel are to be found in a garden, the wind is sure to carry the seeds all over it.

Mrs. B. The distinction between weed and flower is not so easily made as you may imagine. In botany we know not what weeds are; every plant has its use for some purpose or other.

702.—In evaporation of the sea water why do not the saline particles rise high? 703.—Is salt needed in these evaporations as a tonic? 704.—In kelpwort what is mentioned as being remarkable? 705.—To what is this owing? 706.—What plants are common to Europe and America? 707.—Why are these common to the two countries? 708.—What is said of weeds and plants?

We have already noticed the beneficial effects of the motion which the wind communicates to trees. That of the palm-trees in Egypt is so powerful, when agitated by a high wind, that the French, when in that country, made use of them as levers to draw up water from the Nile. The motion of the stems raised the piston of the pumps, which fell again by their own weight.

Of the temperature of the atmosphere, which is the point of greatest importance in vegetation, we have already fully treated. I have only to add, that plants which grow in the plain, in countries of high latitudes, if transported to a warmer climate, must be cultivated in elevated situations. In Chili, for instance, potatoes grow at an elevation of nine thousand feet higher than they will grow in these climates.

Emily. The degree of latitude is, then, the inverse of the degree of elevation from the level of the sea?

Mrs. B. The one serves as a compensation for the other. It is not, however, every species of plant which can take advantage of this sort of compensation; but the greater number of plants will grow equally well at a high latitude in the plain, or in a low one on a mountain.

In an estimate made of the greatest height at which several different species of trees will grow in the south of France, it appears that

The Larch grows at an elevation of	7200 feet.
The Birch	6000 feet.
The Beech	4000 feet.
The Cherry	3000 feet.
The Walnut	2400 feet.
Among the *Cerealia*,	
Rye	6000 feet.
Wheat	5400 feet.
Turkey Corn	3000 feet.
The Vine 1800, or even so high as	2400 feet,

if the situation be particularly favorable.

Emily. I recollect woods of birch-trees on the mountains of Scotland, where they had to struggle against the

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709.—Of the palm tree in Egypt? 710.—Of potatoes in Chili? 711.—Of the correspondence between latitude and elevated situations for the growth of plants? 712.—At what heights, will Larch, Birch, Beech, Cherry, and Walnut grow? 713.—And at what heights will Rye, Wheat, Turkey corn, and the Vine, grow?

difficulties both of elevation, of latitude, and of situation; but, it is true, they were ragged and dwarfish, and wore the appearance of great distress.

Mrs. B. And yet their elevation was far below 6000 feet; for Bennevis, the highest mountain in Scotland, does not rise more than 4370 feet above the level of the sea. The larch, which is much more hardy, has been planted upon the mountains of Scotland with great success, and clothes their once-barren sides with a delicate foliage.

The olive-tree will not grow in a higher latitude than the southern provinces of France; and there it is only under the most favorable circumstances of soil and aspect that it can be cultivated, at the height of 1200 feet.

Caroline. We have seen it in Italy growing almost to the summits of the mountains. I own that I was disappointed with the Italian olive. We associate so many pleasing and poetic ideas with the olive-branch, that I expected it to partake of the beauty of its rival in the gardens of Parnassus—the laurel; but, so far from vying with it in beauty, the color of the olive is so dingy, that it looks like a willow covered with dust.

Mrs. B. I cannot see what reason there is to expect much similitude of appearance between the emblems of glory and of peace. The branching of the young olive is, however, remarkably elegant, and the lightness of the foliage atones for the want of vivacity in its color; and, when mixed with plants of a more lively green, affords a very agreeable variety. The olive-groves of Tivoli gave me the impression of the most antiquated trees I had ever beheld: their venerable trunks are torn, riven, and twisted into a thousand fantastic forms; a profusion of young branches, decked with light foliage, shoot from these aged stems, and, waving their silvery tints in the sun, seem to smile and say, We are your cotemporaries; but the antiquated parent whence we spring once put forth branches under the shade of which Cicero and Mecænas reposed.

Caroline. They are the only olive-trees I ever admired. Independently of their magnitude, they are interest-

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714.—What is said of the growth of the birch, and of the larch in Scotland? 715.—And of the olive tree in the south of France? 716.—What does Mrs. B. say of the branching of the young olive? 717.—And of olive groves of Tivoli? 718.—What is the first and most important way in which water acts upon plants?

ing from their appearrance of age and decrepitude. The stems, so curiously split asunder, look as if they bid defiance to the violence they have suffered; and, twisting the dismembered remnants of their stems together, seem to verify Æsop's fable of the bundle of sticks, and acquire additional vigor to withstand the attacks of time and of the elements.

CONVERSATION X.

ON THE ACTION OF WATER ON PLANTS.

Mrs. B. WATER may be considered as acting on plants in several different ways: the first and most important of which is, its being the vehicle of their nourishment. The greater the quantity of nutritive particles which water contains the more favorable it is to vegetation, unless it should be so far saturated as to be too dense to pass through the pores of the spongioles. In that case the plant is reduced to the state of Tantalus, and perishes of famine in the midst of plenty.

We have already observed, that, of three particles of water which enter a plant, one only remains within it; and this either retains its natural liquid state, analogous to the water of crystallisation in minerals, or is decomposed, to contribute to the formation of oils or other peculiar juices of vegetables.

In the second place, water acts mechanically on plants, by dilating them, and rendering them supple. The woody fibre absorbs water abundantly, but not the bark. The former is often so swelled by this absorption as to burst and split the bark.

Caroline This is no doubt one of the causes of the roughness of the bark of many trees, such as the oak and the elm, which are so seamed and severed into small parts.

Mrs. B. Yes; these, in the course of time, dry and fall off. In other trees the bark remains smooth, but peels off when split by the swelling of the wood.

719.—In what proportion is water favorable to vegetation? 720.—What is said of the one particle of water out of the three which enter a plant, which continues to remain in it? 721.—What is the second way in which water acts upon plants? 722.—How does this sometimes cause the bark to burst?

Emily. But how can the wood absorb water if it does not pass through the bark ?

Mrs. B. The wood absorbs water by the internal vessels. If the trunk of a felled tree lie on the ground in a damp spot, with the roots and branches cut away, so as to leave the vessels exposed at both ends, it will absorb so much water as frequently to make it sprout small branches and leaves.

Emily. I recollect seeing an instance of this in Kensington Gardens : the log was lying in a dell, partly immersed in water, and the whole of it was sprouting with verdure.

Mrs. B. Thirdly, water conveys air into plants ; and the more it is impregnated with air, whether atmospheric or carbonic acid, the better it is adapted to vegetation. Thus the water of large rivers which flow rapidly, and pass over a great extent of country exposed to the influence of the atmosphere, is much more favorable to vegetation than that of small rivulets, which have not been a sufficient length of time in contact with the atmosphere to become impregnated with air : yet this latter is preferable to the water of a lake, which has no current ; for it requires motion, and pretty strong motion, to mix water and air together in the quantity which is required by plants. Large lakes, such as that of Geneva, it is true, are considerably agitated by the wind : the waves then swallow up a certain quantity of air ; but when tranquil it contains much less than river water.

Caroline. Yet is not the water of ponds preferred to that of rivers for watering plants, although it is so tranquil as frequently to become stagnant, and to be covered with a green slime, which shows that it can have been little agitated by the wind ?

Mrs. B. This green scum is a vegetable production, affording food to numerous swarms of the insect tribe, flies, worms, snails, &c. In a short space of time this little ephemeral population, as well as the vegetables which nourished it, perish, and putrefaction succeeds, as

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723.—How does wood absorb water if it does not pass through the bark? 724.—What illustration of this does Mrs. B. give? 725.—And what one does Emily give? 726.—What is the third way in which water operates on plants? 727.—Why is the water of a large river more favorable to vegetation than that of small rivulets? 728.—And why is the water of small rivulets more favorable to it, than the water of lakes? 729.—What is said of large lakes, as that of Geneva, in relation to this matter?

you may frequently have discovered by the offensive effluvia exhaled by ponds and marshes of this description; but the corrupted waters, disgusting and deleterious as they are to us, afford a feast of abundance to the vegetable creation. Saturated with the decayed remnants of both animal and vegetable matter, and replete with carbonic acid, they convey these rich materials for fresh vegetation into the roots of the living plant.

Caroline. The only danger, then, is lest the fluid be too abundantly laden with food, and the plant be gorged with it.

Mrs. B. As plants are not capable of acquiring the virtue of temperance, Nature has wisely provided against their suffering from excess, by giving them mouths of such very small dimensions, that they cannot take in more than is good for them. The only danger, therefore, is, lest the fluid should be too dense to obtain entrance at the roots.

The water least appropriate to plants is that of springs; and, when obliged to use it, we should endeavor to remedy the double defect of a deficiency both of air and of temperature, by leaving it exposed during some length of time to the atmosphere. If the reservoir in which it is contained be situated in the neighborhood of a farm-yard or stables, the water will become impregnated with carbonic acid evolved by the manure. Advantage may also be taken of such a vicinity to enrich the water of the reservoir, by conveying a small stream through the manure into it.

Emily. But spring water is not always of a lower temperature than the atmosphere: during a frost it is evidently warmer, being sheltered from the cold by the depth whence it rises.

Mrs. B. Plants do not then require water: it is in summer that this artificial aid is wanted, and never at a season when the temperature of spring-water is higher than that of the atmosphere.

Emily. One cannot sufficiently admire the beautiful provision which Nature has made for watering her vegetable creation. The rain, falling in small drops through

730.—Why does Mrs. B. say the water of ponds is good for plants? 731.—What is the only danger to plants arising from the water by which they are nourished? 732.—What water is least appropriate to plants? 733.—What will be the effect upon water if in a reservoir situated near a farm yard? 734.—At what periods do plants require water?

the atmosphere, acquires its temperature, and becomes impregnated with air.

Caroline. Yet rain-water can contain no nourishment, unless it be a little carbonic acid it may imbibe from the atmosphere in passing through it; for rain, consisting of pure vapor exhaled from the surface of the earth, can hold no nutritive particles in solution.

Mrs. B. Observe that, when rain falls on a plant, it merely refreshes the foliage, by washing off the dust, and cleansing the evaporating pores, which may have been clogged during the drought. Rain cannot feed the plant as it falls from the clouds; the absorbent pores, you know, are not exposed to its influence: in order to perform this second function it must penetrate into the earth in search of food, and, dissolving whatever it meets with appropriate for that purpose, convey it to the roots of the plant.

Attention must be paid to the proper time and season for watering plants. They do not require it at all in winter, when growing in the open air; because, during that season, they cease growing, and, consequently, stand in no need of nourishment; indeed, they often absorb more water from the wet soil in winter than is good for them. Green-house and hothouse plants should be watered with great moderation in winter: it is time enough to supply them when they ask for it, which you may perceive by their leaves beginning to droop and wither. As spring approaches, the quantity of water must be increased, in order to feed the young buds, which call up additional sap; but the increase must be made with precaution, the earth being still moist with the winter rains. Plants at this season should be watered in the morning, in order that they may not be overloaded with moisture during the night, which would be dangerous should a frost chance to occur; besides, by watering in the morning you provide for the evaporation of the day.

Emily. Yet our gardener generally prefers waterin' in the evening, if he does it only once a day.

735.—What property suited to the nourishment of plants do drops rain acquire in descending through the air? 736.—In what way c rain benefit plants as it falls upon them? 737.—How does rain wa become fitted to nourish them? 738.—Why do not plants in the open air require watering in the winter? 739.—What is said of watering green house plants in the winter season? 740.—In the spring why should they be watered in the morning?

Mrs. B. In the midst of summer the plant, exhausted by evaporation during the heat of the day, requires water in the evening to revive it; there is then no danger of its suffering from frost during the night. In Switzerland, where heat and light are much more powerful than they are with us in England, it is generally necessary to water plants both morning and evening: the earth is dry; and it is difficult in summer to provide for the immense increase of the absorbing and evaporating functions.

There are some plants which grow perfectly well on the Alps, because they are, throughout the summer, watered by streamlets supplied by the melting snow: these same plants perish on the Jura, or any other mountain which is free from snow in summer, because they are not furnished with so regular a current of water.

In autumn, trees which bear pulpy fruits, such as the peach and the plum, require a great deal of water to fill out and to ripen the fruit. Fruits of a dry nature, such as nuts and dates, do not need so much; and the precaution of watering in the morning is equally necessary as in the spring, lest the plant should be surprised by a frost during the night.

Caroline. Grasses and herbs, I suppose, require more water than trees; for, consisting chiefly of leaves, they must undergo a greater evaporation.

Mrs. B. Yes; and annual grasses the most of any.

Seeds which are beginning to germinate, should be watered very sparingly; for the seed, feeding at first on its own proper substance, is rather in want of air than of water; but as soon as it has put forth roots, and a stem has sprung up, it will require a more plentiful supply until the time of flowering, when it must again be restricted, because the blossom is nourished by its own peculiar juices elaborated by the leaves; and when the seed ripens, if it be of a dry nature, still less water must be given.

The quantity of water depends, also, upon the nature of the cultivation. You must consider what is the pro-

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741.—Why in summer should they be watered at evening? 742.—What is said of watering them in Switzerland? 743.—And of some plants which grow on the Alps? 744.—What is said is needed by different trees to ripen their fruit in autumn? 745.—Why do grasses and herbs require more water than trees? 746.—Why should seeds beginning to germinate be watered sparingly; and how should the water afterwards be proportioned?

duce you wish to favor, and water accordingly: if it be a meadow, leaves and not flowers will be your object; therefore you must water profusely, since abundance of water is favorable to leaves and prejudicial to flowers. If it be a field of corn, it is the grain you would favor; therefore you must water sparingly. Rye is cultivated sometimes with a view to the grain, and sometimes chiefly for the straw; in the first case you must water but little, in the latter abundantly.

The siliceous soil of Ireland is very favorable to the culture of corn: this earth not being retentive of water, the abundant rains of that country do not injure the crops. A similar soil in France will not admit of the cultivation of corn; because the climate being much hotter, the corn requires more water, and can be raised only on an argulaceous or clay soil, which retains the water.

Emily. In watering fruit trees, I have observed the gardener dig a trench round the tree, at some little distance from the stem, and pour the water into it, instead of watering close to the tree.

Mrs. B. A judicious gardener will apply nourishment to the mouths of the plant it is to feed. Now these, you know, are situated at the extremity of the roots; and, as the roots spread out beneath the soil, pretty nearly to the same extent as the branches above ground, the tree should be watered at the distance of the extremity of the branches from the stem; the closeness of garden culture usually prevents a trench being dug so far from the tree, but the nearer you approximate to it the better. Observe how admirably Nature teaches us this lesson: the head of the tree, in the form of a dome, protects the stem from the rain, like an umbrella: all around the soil is exposed to the rain, and the water penetrates the earth just where the extremities of the roots are situated to receive it. In addition to this, the greater part of the rain, which has washed and refreshed the leaves, trickles down from the ends of the branches, and reaches the ground in the appropriate spot.

747.—How should the meadow, and the corn field be watered, and why? 748.—What is said of the siliceous soil of Ireland? 749.—What is said of it in France? 750.—How does the judicious gardener apply nourishment to the plant? 751.—How much do the roots spread out? 752.—How is the correspondence between the branches and the roots described, as far as their receiving the rain is considered?

Caroline. How beautifully contrived! I shall not in future take shelter from a shower, beneath a tree, without thinking of it.

Emily. What strikes me with the greatest wonder, in these arrangements of nature, is the ease and simplicity of the means employed: it is always a natural consequence—a thing of course; it would require efforts to prevent, rather than to produce such results: the facility with which they are accomplished, does not draw our attention; but when we do observe and study them, we cannot but feel their infinite superiority to the most complicated contrivances of art.

Mrs. B. The greater and more comprehensive the mind that contrives, the more simple, in general, are the means employed; you may admire, therefore, but you can scarcely wonder at the perfection of the economy of Nature.

In order to form correct ideas on the theory of watering, we must distinguish between the means which are natural aud those which are artificial. The former consists in rain, dew, and the melting of snow. Since it is beyond the power of science to augment or diminish the quantity of rain by a single drop, or to accelerate or retard, by a single minute, the period of its falling, we must, with great humility, limit our efforts to the study of the signs of the times and seasons of approaching rain, in order to modify our culture, so that it shall receive advantage and not injury from it.

Emily. Does not the barometer indicate the approach of rain with tolerable accuracy?

Mrs. B. Far from it: according to the most exact calculations, it is found that the descent of the mercury is followed by rain only seven times out of eleven.

Caroline. Then you have the hygrometer?

Mrs. B. That is of little use as a sign of approaching rain: it indicates merely the degree of moisture of the spot in which it is situated, and gives us no insight into the state of the upper regions of the atmosphere.

753.—What strikes Emily with the greatest wonder? 754.—What is necessary in order to forming correct ideas on the theory of watering? 755.—What are the natural means of watering and what is said of them? 756.—What does Mrs. B. say of the barometer as indicating the approach of rain? 757.—And of the hygrometer?

Wind blowing from places where a greater degree of evaporation takes place is one of the most unquestionable precursors of rain. This is the case with winds blowing from the sea; thus the west wind comes loaded with vapor from the Atlantic Ocean, which it deposits on the continent of Europe.

Emily. But why does the south wind bring us rain; we may consider that as coming from the dry heated continent of Africa, for the Mediterranean Sea is too insignificant to impregnate it with vapor?

Mrs. B. The climate of Africa being considerably hotter than that of Europe, a greater evaporation takes place there; the atmosphere dissolves and contains much more water than our colder regions are capable of holding in solution; the air, therefore, as it advances northward, becomes loaded with a precipitation of vapor, which congregates into clouds, and falls to the earth in the form of rain.

Caroline. That is very curious; and a north wind, on the contrary, being able to maintain more vapor in solution in our climate, than it did in the colder countries whence it blows, scarcely ever brings us rain. I have heard that swallows flying low, flies stinging, fowls rolling themselves in the dust, and cattle feeding voraciously, are all signs of approaching rain; pray, are these merely rustic prejudices, or will they admit of an explanation?

Mrs. B. Swallows fly low before rain to catch the insects, which then come nearer to the earth for shelter; they may, also, approach the earth in search of worms, which make their appearance above ground in times of rain; then a species of fly, with an indurated trunk capable of inflicting a wound, frequently makes its appearance on the approach of wet weather; the fowls may possibly cover themselves with dust in order to preserve them from the wet; and cattle may, instinctively, lay in a store of food as a provision against the time they must abandon their pasture to seek shelter from the rain; but I do not pretend to advance these opinions as any thing more than conjecture founded on some appearance of plausibility.

758.—What is one of the surest precursors of rain, and when does it occur? **759.**—What does Mrs. B. say of the rains in England occasioned by south winds? **760.**—What does Caroline say of a north wind, and what does she say, she has heard mentioned as signs of approaching rain? **761.**—What does Mrs. B. say of these signs?

The second mode which nature employs to water plants is the dew. I hope you recollect the very ingenious theory of Dr. Wells on that subject.

Emily. I fear but imperfectly.

Mrs. B. I advise you to look it over;* at present I shall only say that it is founded on Professor Prevost's Theory of Radiant Heat. In proportion as a body radiates, its temperature must necessarily be lowered, unless it be supplied with heat from some foreign source: during the day the sun affords this supply very amply, but after sunset the earth, as well as every object upon its surface cools by radiation. The atmosphere, which radiates much less than the solid earth, preserves its temperature longer; but the stratum of air which is immediately in contact with the ground is cooled by it, and deposits upon it that portion of vapor which the diminution of its temperature prevents it from longer holding in solution. This precipitation is the dew, which you perceive on the grass, after sunset.

Emily. Since it proceeds from the cooling of the surface of the earth, why is it not equally precipitated on gravel walks and pavement?

Mrs. B. Because the stones of which these are composed are not good radiators, and therefore preserve their temperature longer; and if they do not cool quicker than the air with which they are in contact, no deposition of dew will take place. Minerals, and especially metals, are bad radiators; they require no dew: Nature reserves this mode of watering for the vegetable creation: to plants she gives the power of abundant radiation, both to enable them to throw off the heat with which they have been oppressed during the day, and to call down those refreshing showers of dew which restore their vigor. One knows not which most to admire, the wise provision which is thus made for the benefit of the vegetable kingdom, or the simplicity of the means by which it is accomplished.

* See Conversations on Chemistry, Con. vii.

762.—What is the second mode which nature employs to water plants? 763.—On what is the theory of dew founded? 764.—How does Mrs. B. explain the theory of dew as caused by radiation of heat? 765.—Why is there not dew on gravel walks and pavements, if it is occasioned by radiation? 766.—What is said of minerals, metals, and vegetables in relation to this subject?

Caroline. I imagined that the dew fell from a considerable height; for trees afford a shelter from it: you seldom find any dew beneath a tree?

Mrs. B. The radiation of the earth is stopped by the canopy of the tree and reflected back to the ground, thus preventing it from so rapidly cooling as to occasion a deposition of dew. For the same reason, when the sky is covered with clouds, the heat is reflected back to the earth by them, and little or no precipitation of dew takes place; while, on a clear night, the radiation goes on uninterruptedly, the earth cools rapidly, and an abundant dew is deposited.

Emily. How admirably this provision is proportioned to the wants of the vegetable creation! A clear sky, which leaves it exposed throughout the day to the ardor of the sun's rays, insures it an abundant supply of refreshing dew in the evening.

Caroline. I have seldom perceived this radiation of heat in England; but in Switzerland it is very sensibly felt on a summer's evening, from trees, walls, and other buildings which have been heated by the sun during the day.

Mrs. B. It is for this reason, that, in hot climates, the public walks are less planted with trees, than those of more temperate regions; in the former you can walk out only after sunset, when the neighborhood of trees is attended with every disadvantage. They prevent the free circulation of the cool evening air. They reflect back the heated radiation of the earth, and are, themselves, a source of heat by their own radiation.

Emily. In our more temperate climate, when we frequently walk out during the day, trees afford us a grateful shelter from the sun, and in the evening they have the advantage of retaining the heat and preventing the deposition of dew.

Mrs. B. In regard to the third mode which nature employs to water plants, the melting of snow, as it relates only to plants growing on the Alps, or other mountains whose summits are constantly covered with snow, it is unnecessary to make any observations upon the subject.

767.—Why is there little or no dew under trees? 768.—And why less in a cloudy than a clear night? 769.—What does Caroline say she has seen of radiation in England and Switzerland? 770.—What does Mrs. B. say of trees upon the temperature in the evening? 771.—What is the third mode of nature in watering plants?

CONVERSATION XI.

ON THE ARTIFICIAL MODES OF WATERING PLANTS.

Mrs. B. We shall now proceed to examine the artificial modes of watering, which may be divided into three classes.

1st. By watering-pots or engines.

2nd. By filtration.

3d. By irrigation.

The first mode applies merely to horticulture, for the use of watering-pots can scarcely be extended beyond the garden and greenhouse; the plain spout is calculated for watering the roots, that pierced with holes for washing the leaves, and for watering seeds, young sprouts, or delicate plants which require to be watered sparingly.

If the soil be light, or the plants situated near the high road, or exposed to the smoke of a town, they require more water to refresh the leaves; for if the stomas are choked, evaporation is checked, and vegetation injured: in order to render your plants healthy, they must not only be well fed, but kept clean.

Emily. Green-house and hot-house plants being sheltered from the dust, will, I suppose, not require so much precaution?

Mrs. B. On the contrary, they are exposed to the dust which arises from their cultivation within doors, and deprived of the natural means of getting rid of it, the wind, which in the open air prevents the dust from accumulating on plants: this artificial mode of raising plants, therefore, requires more attention to cleanliness than when grown in the open air; and gardeners frequently use a bellows as a substitute for the wind.

Caroline. Is it not a good way of keeping greenhouse plants moist in the summer to bury them in their pots in the earth?

Mrs. B. Yes, provided they are taken up occasionally, in order to cut off the roots, which shoot through the aperture at the bottom of the pot; for if this operation be

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772.—What are the artificial modes of watering? 773.—To what does the first mode apply? 774.—When do plants require an additional quantity of water, and why? 775.—What is said of the dust which collects on greenhouse plants? 776.—And of burying the pots of greenhouse plants in the summer?

delayed till they are housed in the autumn, the roots will be so bulky as to render their amputation dangerous.

Caroline. Yet is it not the nourishment which the plant obtains from the soil, by shooting its roots through this aperture, which gives it so much vigor?

Mrs. B. True, but the small fibres which sprout out after cutting away the projecting roots are sufficient for this purpose. The main object of the aperture at the bottom of the vase, is in order that the water may filter through; without this resource it would become stagnant around the roots, and rot them. The opening is, you know, partially closed by a piece of tile, leaving not more room than for the water to escape which is not absorbed by the roots; but when water is not supplied to the plant in sufficient quantity, the fibrous roots insinuate themselves through the aperture to search for it in the soil beneath.

Watering by filtration is adapted to two classes of plants; those which suffer from excess, and those which suffer from scarcity of water: it may be performed in two ways, the one is by enclosing the vase which contains the plant, in a larger one full of water, and then burying the double case in the earth, the water will filter from the outer into the inner vase, which must not, of course, be glazed, but of a porous texture. The other mode is to place a pot of water contiguous to that which contains the plant, and connect them by means of a skein of worsted which will act as a syphon, and transfer the water to the vase in which the plant grows.

In the Isle of Corfu I have heard that it is usual to water the orange trees by surrounding them, at the distance of the extremities of the roots, with very porous pots of water; the water oozes through into the ground, and is sucked up by the spongioles.

Meadows are commonly watered by filtration, small trenches are dug, into which water is occasionally made to flow, and thence it filters into the adjacent soil; these trenches should be rather below the surface of the soil,

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777.—What is said of cutting the roots which project through the aperture of the pot? 778.—For what purpose is this aperture? 779.—To how many classes of plants is filtration adapted? 780.—What is the first? 781.—What is the second? 782.—What is the mode of watering orange trees in the Isle of Corfu? 783.—How are meadows commonly watered?

in order that the water may the more easily penetrate to the roots of the grass.

Emily. The trenches are, I suppose, left open in order that the water may derive the benefit of exposure to the air?

Mrs. B. They are sometimes buried in the soil, and at others left open. The first have the advantage of economising the soil, as the ground above them may be cultivated; loss is also prevented by evaporation; yet I prefer the open trenches, both on account of exposure to the air and as affording facility for repairs, which are often required.

3dly. Watering by irrigation consists in conveying the fluid through small channels similar to those used for watering by filtration, but which are made, at pleasure, to overflow the adjacent ground. In order to accomplish this, it is necessary to be furnished with an ample supply of water; if it can be obtained from a superior elevation the operation is greatly facilitated. When, on the contrary, it is necessary to raise it from rivers or wells, various mechanical means may be resorted to. The current of a river may be used to turn a wheel furnished with small buckets, which, during one revolution of the wheel, fill with water, raise it, and pour it into the reservoir prepared to supply the rivulets of irrigation: when there is no current, horses may be employed to turn the wheel.

The hydraulic ram is another mode of raising water. M. De Candolle mentioned one, which, put in motion by a fall of water of twenty feet, raises a body of eight cubic feet per minute to the height of one hundred and sixty feet.

Emily. I should think a steam-engine would afford the most effectual means of raising water; is it not used for this purpose?

Mrs. B. Very frequently, for draining mines; but it would, I conceive, be too expensive a mode of raising water for the purpose of agriculture; at least, I never heard of it being so applied.

It is to be regretted that the rain water which is wash-

784.—What does Mrs. B. say of the two kinds of trenches used for filtration? 785.—In what does watering by filtration consist? 786.—How may water be raised from a river for filtration? 787.—What is the mode of raising it mentioned by Candolle? 788.—Why may not the steam engine be used?

ed down from the roofs of houses should not be turned to account; soiled as it is by this operation, it would but be the better calculated for the nourishment of plants; and it might easily be collected into a reservoir, instead of being carried off, as it usually is, by the common sewer.

It is singular that we should have first learnt artificial modes of watering from the Moors of Spain; their labors in that department were very extensive. Near Alicant they constructed a wall between two hills in order to retain the water which flowed through the valley, for the purpose of irrigating the adjacent country. This wall, which is still in existence, is only twenty-four feet in length at the base, this being the breadth of the valley; but the hills receding as they rise, it is two hundred and sixty feet long at the top, and sixty-seven feet in depth; which is much more than is required to withstand the force of the waters it confines; but the Moors were not versed in the laws of hydraulics.

There are various modes of irrigation: the inundations are sometimes flowing, sometimes stagnant; sometimes stransitory, at other times permanent, according to the nature of the culture. Of the latter description are the rice plantations: this plant requires such abundance of water, that the inundation is drawn off only when the grain begins to ripen.

Emily. I remember, in Lombardy, seeing the green tops of the rice peeping through their watery bath, and looking not very unlike the green scum which frequently covers pools of stagnant water. Nor does it appear to be less pernicious; for I have heard that the cultivators of these rice fields are often afflicted with a frightful cutaneous disease, which terminates frequently in madness and self-destruction.

Mrs. B. The cultivation of rice is certainly not a healthy employment, owing to the stagnant waters in which it is raised; but the disease to which you allude, called the *Pelagra*, is supposed to proceed from feeding on maize, or Indian corn, improperly prepared. The ori-

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789.—What does Mrs. B. say of the rain water which falls on the roofs of houses? 790.—From what was learnt the artificial modes of watering? 791.—What account is given of a wall constructed for this purpose near Alicant? 792.—What are the various modes of irrigation. 793.—What does Emily say she has seen in Lombardy? 794.—From what proceeds the disease called Pelagra?

gin of this dreadful malady was for a long time an inexplicable mystery; and it is only lately that Dr. Sette having observed that it was confined to those districts in which the maize, instead of being preserved in the ear, was kept, like wheat, in separate grains, ready to be ground into flour. This led him to suspect that the grain might have acquired some deleterious property; and, on examining it with a microscope, he discovered that that part of the grain, by which it had been attached to the husk, was covered by a species of mould of a poisonous nature; there is, therefore, every reason to believe that this fatal disease arises from feeding on maize in this corrupt state; and if so, the disease might be easily guarded against.

Emily. What a fortunate discovery! The remedy is so simple, it is merely to adopt the usual mode of preserving maize in France and Switzerland, by hanging it up to dry in the ear.

Mrs. B. Certainly. We have hitherto considered only the various modes of administering water; but it sometimes happens that the earth is too moist: it is necessary, therefore, for the purposes of agriculture, to be acquainted with the best mode of draining it. This operation may be performed in several ways. When the locality will admit of constructing a reservoir in a lower situation to receive it, the water may be carried off by subterraneous ducts. These conduits should be filled with pebbles, sufficiently large to leave a free passage for the waters between them.

Caroline. But of what use are the stones? why not leave the channel quite free and open?

Mrs. B. The stones may be considered as forming a sort of loose wall which serves to support the duct, by preventing the top and sides from falling in: the water would soon wear them away, were they not thus defended, and the passage be obstructed.

The operation of draining a marsh is of much greater importance. A marsh is a space of ground on which the water remains too long, either for want of means of running off laterally, or because a layer of clay soil prevents it from filtering downwards.

795.—How did Dr. Sette account for it? 796.—When the earth is too moist, what is to be done? 797.—How may this be done? 798. —What is a marsh?

Caroline. I should have thought that this abundance of water would have been favorable to the culture of many species of plants.

Mrs. B. It is true that marshes cannot be said to be inimical to vegetation in general; for these spots abound with plants, but they are of an aqueous nature, which are good neither for man nor cattle. They afford, however, an ample repast for the creeping things of the earth; and when we condemn noxious weeds and stagnant marshes, we should remember that, though man is lord of the creation, this world was not made for him alone, and that the reptile and the worm have also their share of its enjoyments. When it is required to drain a marsh of small extent, it may be done by planting it with willows, alders, and poplars. These trees being of very rapid growth absorb a considerable quantity of water, the greater part of which they evaporate into the atmosphere. The poplar has also the advantage of affording very little shade; it does not, therefore, interfere with the action of the sun and air, agents which perform very prominent parts in the operation of draining.

Very extensive marshes will not admit of being drained merely by planting. In this case, the mode resorted to is to raise a bank of earth around the marsh, which answers the purpose of a dam, and prevents the water from running into it; for, if once you accomplish this, the marsh is soon dried by the mere process of evaporation. If the marsh be occasioned by a clay soil, the argillaceous earth, which does so much harm by retaining the water after it has entered the marsh, will do as much good by its impermeability when raised in the form of a bank to prevent the water from entering. In digging for this purpose, the earth must be thrown up towards the marsh, so as to leave the trench or ditch external; the water will then run off by this ditch instead of filtering through the dam raised on the other side. The dam should be formed in the shape of a hog's back, and pressed down hard towards the base, in order to prevent the water in the ditch oozing through. The dam or dyke

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799.—Of the plants of marshes what is said? 800.—For what may they be serviceable? 801.—How may a small marsh be drained? 802.—How may a large one? 803.—If the marsh is occasioned by a clay soil, what is said of the argillaceous earth? 804.—In what form should be the dam?

may be planted with trees, the roots of which will help to keep it together, and the evaporation by the leaves will assist in draining it; but care must be taken to thin the branches, in order to give free access to the sun and wind; nor must they be allowed to grow high, lest the wind, having too great hold of them, should loosen the roots, and thus injure, instead of preserve, the dyke. On the side next the ditch it is advisable to plant reeds.

Emily. But how are you to get rid of the water which fills the ditches?

Mrs. B. That depends, in a great measure, upon the locality: it must be carried off to the nearest running water, or to the sea; without a resource of this kind, it would be vain to attempt to drain a marsh. If we can succeed in preventing the external waters from gaining admittance, that which the marsh contains is so soon dried up by evaporation, that care must be taken not to overshoot the mark, and leave an insufficiency of moisture for the purpose of cultivation.

Caroline. Some attempts of this kind appear to have been made towards draining the Pontine marshes; a canal of water borders each side of the road, which is flanked by a bank of earth planted with trees; and when we passed, I saw, with regret, that they were cutting most of them down.

Mrs. B. It was probably found, that more injury was produced by their shade, than benefit derived from the evaporation of their leaves. But this attempt at draining the Pontine marshes is of a very circumscribed nature, and attended with little success; although the vicinity of the sea affords facility for carrying off the water, the difficulty of draining these marshes has never yet been surmounted.

When marshes are situated below the level of the sea, as is generally the case in Holland, to drain them is a very laborious undertaking, and requires all the patient persevering industry of the Dutch to accomplish. They begin by making the water run off into canals, and then raise it, by mechanical means, into more elevated channels, till it attains an elevation above the level of the sea.

805.—What is said of planting trees upon it? 806.—How is the water filling the ditches to be removed? 807.—What is said of draining the Pontine marshes? 808.—How are the marshes of Holland situated? 809.—How are they drained?

Caroline. But the level of the sea varies according to the tides, being many feet more elevated at high water than at ebb tide?

Mrs. B. The medium must therefore be taken as a general level; and, raising the most elevated canals above that, let off the water at ebb tide into the sea: the canals are furnished with locks, which are then closed, to prevent the water returning when the tide flows. The mode used in Holland to raise the water from the lower to the upper canals consists of a species of small windmills: as the wind blows regularly, though not violently, in that country, they perform their office very well. The same process of windmills is adopted in Cambridgeshire and Bedfordshire.

Emily. Pray can you explain to us the mode in which the valley of Chiana in Tuscany, which was anciently an unwholesome marsh, has been brought to such a beautiful state of cultivation as it now exhibits?

Mrs. B. The marshes in Tuscany are formed by the waters which flow from the Apennines, and which, not finding a sufficient vent, are arrested in their course, and becomes stagnant. The Apennines being of a loose sandy texture, the waters bring with them a great quantity of earth, which they deposit in the lowest parts to which they flow.

Caroline. I recollect that the Arno, when swollen by rain, is quite thick with mud, brought down from the mountains by the torrents which feed it.

Mrs. B. The celebrated Torrecelli took advantage of the deposition of this mud to invent a mode of draining the marsh of the Chiana. But before I explain the remedy, it will be necessary to inform you whence the evil arose, and give you an account of the origin of this marsh.

In ancient times, the numerous rivulets which flow from the adjacent hills into the valley of Chiana poured their united waters from thence into the Tiber. Some inconvenience being experienced by the Romans, from occasional overflowing, they constructed a dyke to close this outlet. The waters, thus stopped in their course, formed a lake, which, when raised by accumulation to a

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810.—How is the level of the sea situated? **811.**—What is the mode of raising water in Holland? **812.**—How are the marshes of Tuscany formed? **813.**—Who invented the mode of draining the marsh of the Chiana? **814.**—In what manner was the lake first formed?

certain elevation, found an issue to the north, precisely in the opposite direction to that in which the water formerly flowed out of the valley. The rivulets, therefore, on entering the valley, were all obliged to change their course. In making this turn, their velocity was diminished; and having no longer power sufficient to carry with them the earthy materials with which they were laden, these were deposited in the lake, in which they accumulated, and, in the course of time, converted it into a marsh. The ingenious and sagacious Torrecelli availed himself of the evil to devise a remedy; and employed the very means which had converted the lake into a marsh to convert the marsh into dry land.

Emily. That was a most happy idea; but how did he accomplish it?

Mrs. B. He caused a mound or bank of earth to be raised towards the base of the hill, around the part where a rivulet changed its course. This was left open on the most elevated side; so that the water, laden with earth, in its descent might have free access to it; on the lower side a small aperture was made through which the water alone could escape, leaving behind the earthy matter, with which it was saturated. In the course of time, the soil within this enclosure, was elevated by the accumulation of earth, above the level of the stagnant water; and rose, like a dry little island, on the edge of the marsh. A contiguous enclosure was then made, and raised by similar means; a third and a fourth followed in succession. These labors have been going on during two centuries: of late years they have been prosecuted with great activity and sagacity by the celebrated Fosombroni of Florence; and only a few years more will be required to complete them. Already you have beheld this district transformed, from a melancholy and pestilential marsh, into a richly cultivated valley, watered by a clear stream, the result of the torrents purified from their earthy deposits.

Caroline. It is, indeed, quite a metamorphosis; and is not this mode adopted in other countries?

Mrs. B. It is frequently employed in the environs of Bologna, and in several other parts of Italy. This ope-

815.—Why was the mud deposited instead of being carried away with the water? 816.—What was the plan of Torrecelli? 817.—How long have these labors been in operation? 818.—What is the present condition of this valley? 819.—Where else has this mode of operation been adopted?

ration is called in Italian *colmare*, in French *combler*, that is to say, to *fill up*. I once, in travelling, saw it carrying on, in a spot on the declivity of a hill; for you understand that it can take place only where the ground slopes, so as to enable the waters to run off.

Caroline. When the mountains, from which the rivulets bring down the earth are of schist, like the Apennines, this operation must be much more easily effected than when they are of granite, for the harder the earth the less earthy matter the waters can wash down.

Mrs. B. When the mountains are of granite, no deposition of earth takes place to interrupt the course of the streams, and produce a marsh: the evil cannot exist, and the remedy is not required.

Emily. But elaborate and artificial as this mode appears, it is, in fact, precisely that which Nature employs to level the inequalities of the globe: the streams are ever conveying earth from the mountains to deposit it in the vallies, thus lowering the one and elevating the other.

Mrs. B. That is perfectly true: it is thus that the plains in the north of Italy, between the two ridges of the Alps and the Apennines, have been formed. The rivers flowing from these long chains of mountains have deposited their solid contents in the intervening low lands, raised and united the several vallies, and levelled them into plains, such as those of Lombardy and Liguria; and, had Nature been allowed time to complete her work, they would have been elevated to a height which would have preserved them from danger; but impatient man was eager to inhabit this alluring paradise, before its creation was completed. Hence, instead of profiting by the gratuitous labors of Nature, who was gradually preparing it for his reception, he has been compelled to repair by artificial means, at the expense of immense toil and trouble, the evils resulting from the interruption given to her operations.

Emily. But of what nature are those evils?

Mrs. B. Inundations produced by the quantity of turbid waters, which in rainy seasons, is frequently so great, as to overflow the whole country, and destroy cultivation.

820.—What is it called? 821.—What is the consequence if the mountains are of granite? 822.—Where else have similar plains been formed? 823.—Why was this work of nature interrupted? 824.—What evils resulted from the artificial means?

The inhabitants, therefore, found it expedient to put a stop to this levelling system of Nature by embanking the rivers, in order to confine the waters within their beds.

Caroline. We observed that in Lombardy and in Tuscany the rivers were generally embanked: but I should have thought that such a measure would have afforded but a temporary remedy; for those very sands, which Nature would have employed to raise the general level of the plains, being deposited at the bottom of the rivers, would in the course of time, so raise their beds, that the waters would overflow the embankments.

Mrs. B. Very true; their only resource was to raise the embankments in proportion as the bed of the rivers were elevated. In consequence of this elevating system of art, in opposition to the levelling one of Nature, the Adige and the Po are higher, than the plains which separate the two rivers; and it is thought that it will be ultimately necessary to form new beds for their waters, in order to avoid the ruin they threaten.

The plains of Holland derive their origin from a similar process; but they are exposed to still greater dangers than those of Italy, lying so low as to be menaced not only by the overflowing of the Rhine and the Moselle, from the shallowness of their beds, but by inundation of the sea. Every defence which art can afford, such as embankments, dykes, canals, &c., has been achieved by the patient and industrious inhabitants of that enterprising country; yet the resistless ocean frequently breaks in upon them, and destroys all their labors.

Emily. What a prodigious quantity of earth and sand these rivers must carry into the sea! It is well that its bed is too deep, to be affected by such depositions.

Mrs. B. It is true there is no danger of their occasioning an overflowing of the sea: important effects, however, are frequently produced on its shores. The impulse of the rivers is diminished on reaching the sea, by that of the waves they have to encounter. Sometimes their waters are partially repelled back on the shore, where they

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825.—What does Caroline observe of the rivers in Lombardy and in Tuscany? 826.—What is said of the Adige and the Po? 827.—Of the plains in Holland? 828.—How are inundations there prevented? 829.—What consequences result from rivers losing their velocity on encountering the waves of the ocean?

form marshes: districts of this description abound on the coast of the Adriatic. Sometimes they deposit their solid contents in one large bank, when their current is first repulsed by the waves of the sea, and form at the mouth of the river a plain or Delta: such is the Delta at the mouth of the Nile.

Caroline. And if we may be allowed to compare small things to great ones, such I suppose is the origin of the Delta or low land at the mouth of the Rhone, on entering the lake of Geneva from the Valais. And the Isle of Camarque, formed by the deposition of the waters of the Rhone at its entrance into the sea, offers a still more striking example.

Mrs. B. Sometimes, the rivers have sufficient power to struggle against the resistance of the waves, and do not deposit their mud and sand, till they have advanced to some little distance in the sea; when their waters, broken and divided by the waves, precipitate their cargo in separate spots, forming a number of small islands; hence the origin of those on which Venice is built.

We have prolonged our conversation rather beyond bounds to-day; I have but one more remark to make to conclude this subject.

When it is required to resist the force of an irregular mountain-torrent, a number of small embankments is preferable to one large dyke, however strong; for during violent rains there is some danger of the dyke being carried away, while several small embankments successively break the force of the waters.

CONVERSATION XII.

ON THE ACTION OF THE SOIL ON PLANTS.

Mrs. B. Our last conversation was upon water: today we shall change the subject to dry land. It has been asserted, that earth was not absolutely essential to vegetation, because there are some plants which do not re-

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830.—What instances of illustration are named? 831.—What ones in Europe does Caroline mention? 832.—How were the islands on which Venice is built formed? 833.—What is said of the earth as being essential to vegetation?

quire it, which live in water, whence they derive their nourishment: but this class is very insignificant. The earth affords both support and nourishment to plants

Caroline. Or should you not rather say, is the vehicle of their nourishment, since their food is composed principally of animal and vegetable remains?

Mrs. B. Very true; the various saline particles which plants pump up from the soil, should rather be considered as flavoring their food, than forming a nutritive part of it: their daily bread is of animal and vegetable origin.

Caroline. And when there is a deficiency of salts to flavor their food, have not plants the power of forming them in their internal laboratory?

Mrs. B. No; the chemical apparatus of their organs is so arranged that it can elaborate only vegetable juices, and is as incapable of forming a salt or an oxide, as an animal is of forming the phosphat of lyme with which its bones are indurated.

Emily. How then are these salts, which are composed of various ingredients, formed?

Mrs. B. The metals intermixed with the earths of which our globe is composed attract oxygen from the atmosphere, and combine with it; and it is thus that the mineral kingdom prepares the oxides, for the use of organised bodies.

The earth, we have said, supports plants, and gives them a fulcrum or point of rest, which animals have not, because they do not require it. In order to support plants, the ground must be neither too compact nor too loose. They cannot grow upon a hard rock, nor in a moving sand: their roots cannot penetrate the first, nor take firm hold on the latter.

Emily. Besides, a plant would find no food to nourish it on a barren rock.

Mrs. B. That most patient and persevering of agriculturists, Nature, teaches us how to prepare a soil, even on the hard rock, or the sterile lava of a volcano: she commences her operations on these obdurate bodies by

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834.—And of the saline particles which the plants receive from the soil? 835.—Caroline asks, if plants have the power of forming salts—what is the answer? 836.—How does the mineral kingdom prepare oxides for the use of organized bodies? 837.—What is said of the ground in order to give support to plants?

means of her elementary agents, air and water. If the rock be of a calcareous nature, the lime is gradually dissolved, a decomposition begins to be effected ; and hence the origin of a soil. If the rock be silicious the operation is more difficult; but Nature, unrestricted by time, finally accomplishes her object. On this shadow of a soil, a vegetation, almost imperceptible from its minuteness, begins to exist : the invisible seeds of lichens, which are ever floating in the air, there find an asylum. Minute as these seeds are, they are furnished with admirable means to attach themselves to hard bodies.

Caroline. What a careful provision Nature has made for the most insignificant of her vegetable kingdom!

Mrs. B. These seeds, once attached to the rock, find sufficient nourishment in the moisture they have absorbed from the atmosphere during their aerial flight to enable them to germinate, but not sufficient to bring them to perfection, and enable them to produce seeds to continue their species; but when they perish, a new race rises, phœnix like, from their remains.

Emily. This is indeed a new mode of raising plants!

Mrs. B. It is these remains, mixed up with some of the crumbled particles of the rock, which constitute the first bed of earthy soil, in which the seeds of more robust lichens and mosses sow themselves, and find nourishment; thus a variety of plants, annually increasing in strength and vigor, rise up in succession, till the dry rock becomes covered with verdure, and ultimately clothed with trees. You see, therefore, Caroline, that you have no more reason to despise the humble plants in whose remains a soil originates, than to underrate the germ of a shoot which may produce a stately oak.

There is another process which nature frequently employs to clothe a barren rock : wherever there are fissures the rain insinuates itself, and by freezing in winter often splits the rock, or at least widens the crevices ; it is in these humid recesses, where the water has crumbled the

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838.—How does nature begin in forming soil upon a rock? 839.—What is the first vegetable appearance? 840.—From whence do the seeds of lichens floating in the air obtain sufficient moisture for germination? 841.—What is the successive process by which soil is formed on rocks from the growth of vegetables? 842.—What is another process by which nature clothes a barren rock?

rock, that seeds bury themselves, and vegetation commences.

Emily. In attempting, then, to cultivate a barren soil, we should follow those lessons which Nature points out, and scatter seed in such crevices, which, if they did not arrive at complete maturity, would, by their remains at least, help to prepare a soil.

Mrs. B. This is often done; for instance, in the fissures of the lava of Mount Etna. Indian fig or prickly pear has been sown; the roots of which insinuate themselves into every little cavity, and help to split the block. This plant produces a great quantity of fruit, but its most important recommendation is, that of forming a soil for future vegetation; but to proceed to soils of a less obdurate nature.

A stiff argillaceous soil is difficult to cultivate, on account of the resistance it opposes to the penetration of roots. This description of soil attracts moisture, and is so retentive of water as to be seldom dry, unless during the heat of summer, when it splits; and it is in the crevices thus formed that vegetation commences. Such a soil requires frequent ploughing, in order to break down and pulverise the clods, when practicable, earth of a lighter nature should be mixed with it. Plants having large roots will not, in general, succeed in a soil of this description, as they will not be able to penetrate it.

Emily. Yet plants with small delicate roots will have still less strength to do so.

Mrs. B. True; choice should therefore be made of roots which have slender, but firm and strong roots: those whose roots are of a dry nature are best adapted to hard, impenetrable soils.

A sandy soil offers difficulties of an opposite description. If the sand be mixed with calcareous matter, these are more easily overcome; for a portion of the lime is dissolved by rain, and its solution gives some degree of stability to the soil: but if the sand be almost entirely silicious, like that of the sea, the evil is well nigh insuperable; for this species of sand is insoluble, and nothing

843.—How is soil formed in the fissures of lava on Mount Etna? 844.—Why is it difficult to cultivate a stiff argillaceous soil? 845.—What is said of large roots in this soil? 846.—What roots are suited to it? 847.—Why is it impracticable to cultivate the deserts of Arabia and Africa?

can change its nature. Hence the impracticability of cultivating the sandy deserts of Arabia, Africa, and various other parts of the world.

Emily. Yet, if such deserts existed in Europe, do you not think that means would be discovered to overcome the difficulty ?

Mrs. B. I doubt it. The wind which blows without restraint over these unsheltered and unstable plains tears up the roots of every tree that is planted.

Emily. But small low shrubs would offer but little resistance to the wind.

Mrs. B. These would soon be buried by the whirlwinds of sand. The plants most likely to succeed would be such as are of moderate stature, with spreading roots to fix them in the soil.

When sands are of small extent they may be improved by mixing clay with them ; and the first crop should be raised solely with the view of ameliorating the soil.

There are three species of sandy soil : that which forms the banks of rivers; that which composes those extensive plains called steppes ; and that which forms sand-hills on the sea-shore. On the borders of rivers, stakes of willow and of alder may be planted with advantage ; being abundantly watered, they soon shoot out roots and branches, which grow rapidly. Then, if with the stroke of a hatchet these branches be lopped, so as to make them trail upon the ground, without being completely separated from the stem, they will soon be covered with the loose soil and will strike fresh roots : these numerous roots shooting out in every direction, are interwoven, and forms a species of net work, which sustains and gives stability to the soil.

In order to bring steppes into culture, which are not so well supplied with water, the first plants raised must have roots which pierce deep into the earth, so that they may find water beneath the sandy soil. The culture of madder has been successfully employed in the neighborhood of *Haguenot*, as the precursor of general agriculture.

848.—Why would they not be cultivated if in Europe? 849.—What would become of low shrubs? 850.—When sands are of small extent, how can they be improved? 851.—What are the three species of sandy soil named? 852.—How is it said that the soil can be improved on the borders of rivers, by planting willows and alders? 853.—How are steppes brought into culture?

It cannot be too often repeated, that when you aim at bringing bad soils into culture, the first produce must be sacrificed for the benefit of the land, with a view to improve it for future harvests.

Caroline. So far as can be judged from the abundance and magnitude of the crops, Belgium appears to be one of the countries in which agriculture is carried to the greatest degree of perfection.

Mrs. B. The beauty of the produce is no bad criterion of the advancement in the art, especially in Belgium, where Nature has done little for the husbandman; but the Belgic peasantry are nearly as well versed in agriculture as the learned of other countries. Their soil is in a great measure the work of art, man having taken possession of it before Nature had completed its formation.

Caroline. Nor does it appear that the art of man has yet finished it; for though the cultivated parts yield such rich crops, an extensive sandy desert, called the Campine, still remains on the confines of Belgium and Holland.

Mrs. B. True; but cultivation advances with gigantic strides across the arid waste. The mode by which the husbandman commences the process of fertilisation in these sterile plains is by sowing Genet of Broom, which grows up in bushes, the roots of which confine the soil, and give it sufficient stability to enable him to sow pines with advantage. These are followed by Acacias; the branching roots of which, stretching out in various directions and interwoven together, sustain the soil as it were in osier baskets. But it is not until this succession of forests have flourished and decayed that the soil enriched by their remains, becomes fit for general culture.

Emily. This, then, is the work of a long course of years?

Mrs. B. Certainly; but still the formation of the soil is rapid, in comparison of what it would have been, if left to be completed by the gradual agency of Nature, who is enabled to prolong her operations beyond the period of our transitory existence, and is therefore less impatient to accomplish her task. We are justified, how-

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854.—What cannot be too often repeated? **855.**—What is said of the Belgic peasantry? **856.**—And of their soil? **857.**—What is the mode of enriching it in order to its becoming fit for general culture? **858.**—What is needed for this renovation?

ever, in taking it out of her hands, if we can produce the effect more rapidly. The sand-hills, which are, in many places, formed on the sea-coast, owe their origin to sand thrown up by the high tide, and which, abandoned by the receding waters, dries, and is carried by the wind farther inland, and out of the reach of successive tides. The sand-hills formed in the vicinity of Bourdeaux formerly threatened the destruction of the adjacent country: it was calculated that no less than seventeen villages would be overwhelmed by them in the course of a century; when M. Bremontier was so fortunate as to discover a means of averting this danger. Observing that sand thus thrown up was not devoid of moisture, he scattered over it the seeds of broom and of maritime pine; and, in order to prevent their being swept away by the wind, he covered them with brambles and branches of underwood. The seed sprouted; the broom first rose above ground, and some time after the young pines appeared: the latter, however, made but little progress, seeming to be choked by the rapid growth of the broom; yet in the course of a few years the pines gained the ascendency, and drove their antagonists from the field; or rather, I should say, like true cannibals, after destroying the enemy, they fed upon their remains.

In the course of time it became necessary to thin this vigorous forest of pines; and their branches served to shelter the seed scattered on neighboring sand-hills.

Caroline. I recollect reading in Withering, that the Arundo arenaria, or sea-matweed, which grows only on the very driest sand on the sea-shore, prevents the wind from dispersing the sand over the adjoining fields. The Dutch have very probably known and profited by this fact.

Mrs. B. Hitherto we have directed our attention rather to the formation of new soils than to the improvement of old ones: yet the latter is the point of most importance in agriculture; for we are much more frequently called upon to ameliorate the land already under tillage than to prepare a soil, on land which has not yet yielded any produce.

Soils may be improved by a variety of different pro-

859.—How are sand hills on the sea coast formed? 860.—What is said of those in the vicinity of Bourdeaux? 861.—By what means was the danger averted? 862.—What is of more importance than the formation of new soils?

cesses: by tillage, by amendments, by manure, and by rotation of crops. These follow each other in natural succession. Man first begins by cultivating the earth; he next endeavors to ameliorate the soil, in order to render it more propitious to the produce he wishes to raise. After having yielded a certain number of crops, he observes that the earth is exhausted of its nutritive principles, and that the crops are poor and meagre. He finds the means of renovating these principles by manuring the land; and, when manure falls short, he discovers that a judicious system of cropping answers, in a great measure the same purpose.

The principal object of tillage is to break and crumble the earth, in order that the roots of young plants may easily penetrate into it; to expose every part of the soil successively to the action of the air, so that such of the earths or metals, as are destined to be converted into salts by the action of the oxygen of the atmosphere may be brought into contact with it, as well as such remains of organic bodies as can be dissolved only by oxygen. Various implements of husbandry are employed for this purpose; and it is a continual object of dispute, between the agriculturists of different countries, which answers the purpose best.

Emily. But is not the plough the instrument universally used in all civilised countries?

Mrs. B. Most commonly; but the plough itself is of various descriptions, and you have observed the peasantry of Tuscany frequently employing the spade, an implement which we reserve for garden culture. They are, indeed, bound by the tenure on which they hold their land to dig it up every third year. The spade undoubtedly performs the operation of turning and subdividing the earth more completely than the plough, but at a much greater expense of labor; and it is an instrument adapted only to light and homogeneous soils, for if the earth be of unequal tenacity, or interspersed with stones, it cannot be used. The pickaxe may in those cases be substituted, as it is

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863.—By what different processes may soils be improved? 864.—What is the succession used in agriculture?—865.—What may be a substitute for manuring? 866.—What is the principal object of tillage? 867.—What is observed of the peasantry of Tuscany? 868.—What comparison is made between the use of the spade and the plough? 869.—In hard soils what instrument is substituted for the spade?

a pointed instrument, which more easily penetrates. This implement is also of various descriptions: it has a single or a double prong, which is broader or sharper, and forms a greater or lesser angle with the handle, according to the nature of the soil.

With the spade the laborer works backward, and throws up the earth before him; with the pickaxe he goes forward, and draws the earth towards him.

Caroline. The hoe, that very useful instrument for weeding or lightly raising the earth, is also used like the pickaxe. But what is the reason that the form of these instruments vary so much, in different countries?

Mrs. B. Sometimes from improved models being adopted in one country, which another, through ignorance or prejudice, will not follow; and perhaps, more frequently, from the different nature of the soil. The spade or the hoe must be light or heavy, broader or more pointed, according as the soil is loose or stiff; for the heavier or more tenacious the earth, the less quantity can be raised at one stroke. But the most important of all implements of husbandry is doubtless the plough: it has been celebrated since the times of Moses and of Homer; and it is the form of this instrument which has produced the greatest contention amongst agriculturists. The plough may be considered as a sort of pickaxe, drawn by animals through the soil. In northern climates husbandmen are great partisans of deep ploughing; in southern countries they are no less staunch advocates for light or more superficial ploughing; and they are, perhaps, each equally right in approving their own mode, and wrong in blaming that of their opponents, for the different species of plough are adapted to the soil of their respective countries.

In high latitudes, where there is much moisture and but little heat, it is necessary to turn over the earth more completely, in order to dry and pulverise it, especially when of an argillaceous nature, which is very common in northern countries. In more southern climes, where heat and drought prevail, it is better to plough more lightly, the soil being frequently of a sandy nature, not retentive of water.

870.—Why do agricultural instruments vary as to their form in different places? 871.—What is said of the antiquity of the plough? 872.—What comparison is made in the mode of ploughing in northern and southern countries? 873.—What is the reason of it?

Emily. But supposing the soil to consist of two layers, the one of sand, the other of clay, the plough should, I suppose, go deep enough to mix them together.

Mrs. B. No doubt their union produces as excellent a soil as their separation makes a bad one. It signifies not which is uppermost before ploughing; the more they are mixed and incorporated together the better.

Caroline. But supposing there should be a good, rich, vegetable soil on the surface, and layers of sterile ground beneath?

Mrs. B. Then a light plough should be used, and as much care taken to prevent the mixture of the two, as to effect it in the former case; in short, attention must always be paid to the nature and locality of the soil. Ploughing must vary, also, according to the nature of the produce to be raised. Lucern, which shoots out roots four or five feet in length, requires deeper ploughing than corn, whose roots are very superficial. Six or eight inches is sufficient depth for grain in general.

Emily. When new land is first broken up, to bring it under tillage, it will, I suppose, require deep ploughing to pulverise the hard earth.

Mrs. B. That also depends on the nature of the soil. In America, where fine rich vegetable soil is daily brought into cultivation, nothing more is required than to scratch the earth with a plough, and scatter the seed, in order to produce an abundant harvest. But in England, and all countries which have long been cultivated, the good soil is already fully employed; and if any new land is ploughed up, it is of a very inferior description, and it is necessary not only to plough it deeply but repeatedly, and to manure it, before it will yield a crop. The operation of bringing grass land into tillage is on the Continent frequently performed by a pickaxe with a double prong, which breaks the earth more completely than the plough.

Another point to be considered in tillage is the quantity of manure to be spread upon the land. If this fall short, and the ploughing has been deep, the nutritive particles may filter down lower than the roots can go in search of them.

874.—What is said of mixtures of clay and sand? 875.—If there be a good, rich, vegetable soil on the surface and layers of sterile ground beneath, what should be the mode of ploughing? 876.—How is the depth of ploughing to be varied from the nature of the produce? 877.—In America what is the nature of the soil, and the mode of ploughing? 878.—And in England? 879.—What is another point to be considered in tillage?

The more tenacious and compact the soil is, the closer the furrows must be, and the narrower the ridges of earth turned up, in order more effectually to pulverise it, and afford channels for the water to run off. When the soil is light, broader ridges and more distant furrows suffice: it is even sometimes necessary to beat down the earth, after having ploughed or dug it, in order to render it more compact, especially in nurseries of young trees, whose roots, in a loose soil, are liable to be torn up by the wind.

Deep furrows, or trenches, are very useful where the ground is sloping, either to draw off or retain the water as required. If the soil be too moist, the furrows should be made longitudinally, that is to say, from the top to the bottom of the acclivity: they will then answer the purpose of conduits to carry off the water. If, on the contrary, the soil be dry, the furrows should be made transversely, and the ridges of earth will act as parapet walls to retain the water.

It is very necessary also, to pay attention to the period of ploughing: it can be done neither in a wet season nor during a hard frost, nor in very dry weather; but as you have the whole season before you, from the reaping of one harvest to the sowing for another, it is not difficult to choose a period of appropriate weather, unless it be in some strong clays, upon which a horse cannot be suffered to tread during the winter. If the ground be intended to lie fallow, the best use which can be made of the repose allowed it, is to plough it in autumn, and again in the spring; but if it is to be sown, the sooner it is ploughed after harvest the better, in order to bury the straw or other remains of the preceding crop, which will enrich the soil, and also prevent the further growth of weeds.

In hot countries the land cannot be ploughed in summer, on account of its dryness; besides, it would afford the means of evaporating the small remains of moisture of the newly turned up earth, and that at a period, when it has its most important functions to perform—those of softening and dissolving the hardest and most insoluble particles, which cannot be done unless the temperature of the water be tepid.

880.—How must the width of the furrows be regulated? 881.—How should they be on sloping ground? 882.—What is said of the period of ploughing? 883.—And if the ground is to lie fallow?

Caroline. But how can it be rendered tepid without exposing it to the sun?—And in that case it will be evaporated.

Mrs. B. Exposure is not necessary: the heat of the atmosphere gradually penetrates the soil, and the water diffused in it acquires the same elevation of temperature. Farmers conceive that the soil is injured by the action of ploughing in summer; but the injury proceeds from impeding the solutions requisite for the following crop. In northern climates, where evaporation is less active, ploughing is not so objectionable in summer.

CONVERSATION XIII.

THE ACTION OF SOIL ON PLANTS CONTINUED.—ON THE IMPROVEMENT OF SOIL.

Mrs. B. We may now proceed to examine the various modes of improving the soil by mineralogical processes. The first and most simple of these is to clear it of stones; when stones are injurious to cultivation.

Caroline. But are not stones always injurious? For of whatever materials they may be composed, they are such hard insoluble bodies that vegetables can acquire no nourishment from them.

Mrs. B. True; but stones often perform a very useful mechanical part in agriculture. They render a clay soil less tenacious by separating its parts, and thus leave room for water to drain off: they form, as it were, so many natural irregular conduits; and, if you take them away, you must employ them for the construction of artificial conduits to effect the same purpose.

Caroline. This may be the case with stones buried in the earth, but those lying on its surface must surely be prejudicial to vegetation?

Mrs. B. Generally they are so, but not universally: in some hot countries grass cannot grow, excepting under shelter of loose flat stones. I have seen pastures of

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884.—In hot countries why should not ploughing be in summer? 885.—How may the soil be rendered tepid? 886.—By mineralogical process what is the first method of improving the soil? 887.—Of what use are stones to a clay soil? 888.—Of what use may stones be when lying on the surface, and what is an example?

this description on the plains of Crace, near Arles. They exhibit the singular spectacle of flocks of sheep feeding on dry stones, as the grass which grows beneath them is not visible; but the sheep find a tender, if not abundant pasture, by turning up these stones, or nibbling beneath them; while the pebbles, thus overturned, afford shelter to the adjacent blades which are just sprouting, and would be burnt up without such protection.

In some instances the ground in which fruit trees are planted, have been paved with stones, in order to retain the moisture beneath by preventing evaporation.

In cold countries stones are sometimes considered advantageous as communicators of heat, those of a dark color especially. They act on the surface of the earth both as reflectors and radiators of heat; and are frequently placed round the stems of plants in a vineyard, in order to give them additional heat. It must be allowed, however, that those occasional uses to which stones are applied in husbandry, are to be considered rather as exceptions to the general rule, and that stones may be looked upon in most cases as either useless or pernicious.

The improvement of soil by the admixture of foreign ingredients, *amendement*, is one of the most important operations of agriculture.

If the soil be too stiff from excess of clay, it will be improved by sand; and if too loose from excess of sand, it will be improved by clay: but when sand is mixed with argillaceous soil, the latter must be broken and pulverised, which may be effected by exposing it to the frost, and afterwards drying it. Marl is a natural compound earth, used with great success in the amelioration of soils: it consists of a mixture of clay and calcareous earth or lime in various proportions.

Argillaceous marl, which contains more clay than lime, is advantageous for a dry sandy soil; while calcareous marl, in which the lime predominates, is suited to an argillaceous soil. The great advantage of marl is, that it dilates, cracks, and is reduced to powder by exposure to

889.—What is said of them in relation to fruit trees? 890.—And what is said of their influence upon the soil in cold countries? 891.—Are stones generally useful in agriculture? 892.—What is one of the most important operations of agriculture? 893.—How are the different kinds of soil to be changed? 894.—What is Marl? 895.—What is said of argillaceous and calcareous marls?

moisture and air. Marl in masses would be totally useless on the ground; yet it is necessary to begin by laying it on the ground in heaps, for the more it is heaped the more it dilates, splits, and crumbles to dust; in which state it is fit to spread upon the ground.

Marl is sometimes intermixed with other earths; sometimes formed into a compost with manure before it is laid on the soil: it should be applied sparingly at a time, and renewed frequently. Its advantages are manifest: it subdivides the soil and accelerates decomposition, its calcareous particles disorganizing all animal or vegetable bodies, by resolving them into those simple elements in which state they combine with oxygen; it facilitates this union: hence, though not itself of a nutritious nature, it promotes the nourishment of plants by preparing their food. The best period for marling ground is the autumn.

Lime is also an excellent *amendement.* It is procured from limestone by exposing it to the heat of the kiln, which evaporates the water and carbonic acid with which lime is always found combined in nature, and renders it *quick,* as it is commonly called; that is to say, of a caustic burning nature, having such an avidity for water and carbonic acid, from which it has been forcibly separated, that it seizes upon these bodies wherever they are to be met with, and disorganises the compounds in which they are contained in order to combine with them.

Emily. But since lime is of so destructive a nature, I should have thought that it would have been necessary to add, instead of subtracting, water and carbonic acid, in order to soften its caustic properties, which seem calculated rather to destroy than promote vegetation.

Mrs. B. Were quick-lime applied immediately to plants, it is true that it would prove a poison to them; but, when spread upon the earth, it rapidly attracts water and carbonic acid from the atmosphere, and it is only when thus modified that it promotes vegetation.

Emily. Then why force from it, in the kiln, those very ingredients which must be restored to it so soon afterwards?

896.—What is said of marl in masses? 897.—With what is it mixed? 898.—How does it operate on the soil? 899.—How is lime prepared, and how does it affect the soil? 900.—If applied immediately to plants how would it affect them?

Mrs. B. In its natural state of limestone it is of too hard and compact a nature to be diffused in the soil; and even quick-lime would be too solid, were it not, that through its combination with water and carbonic acid from the atmosphere, it splits and crumbles to powder.

I believe the experiment of pounding and grinding lime-stone to powder, was tried in Scotland, in order to save the expense of burning it into quick-lime, but not found to be efficacious like the powder of slacked lime.

Lime is particularly adapted to poor cold soils, such as those of marshes, which have not energy to dissolve organic bodies. The quantity to be used must be proportioned to the manure which is laid upon the ground; for the more organic matter there is to be dissolved, the greater will be the quantity of lime required for that purpose. To mix lime with peat-earth, is said to have an immediate and most beneficial effect, and that many bogs, having been previously drained, have been converted into fertile land.

The lime procured from fossil-shells is highly esteemed by agriculturists: its pre-eminence results, probably, from its retaining some vestiges of organic remains of the animals who once inhabited these receptacles.

Caroline. The shells of living animals must then be still more valuable for this purpose?

Mrs. B. They are neither so readily, or so abundantly obtained; large strata of fossil-shells are to be found in some soils, whilst of living shells you could procure at most, the refuse of the fish-market.

Ashes are very beneficial to the soil: they differ much in their composition, according to the nature of the body from the combustion of which they result, but their general ingredients are potash, silex, and calcareous earth. They attract moisture from the atmosphere, and thus accelerate vegetation.

Sulphate of lime, commonly called gypsum, is an excellent *amendement;* but chemists are not agreed as to the manner in which it acts on vegetation. It is strewed over

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901.—Why might it not be used in its natural state? 902.—How was it used, and with what success in Scotland? 903.—To what soils is it particularly suited? 904.—What is said of it mixed with peat? 905.—And of that obtained from fossil-shells? 906.—What is said of ashes and their influence upon soil? 907.—And of the sulphate of lime?

crops when the leaves are in full vigor, towards the latter end of April or the beginning of May, and it should not be laid on more than once in the year. Clover and saintfoin contain gypsum in their stems to a considerable amount; and when soils are said to be tired of those plants, it is probable that they are no longer able to supply this necessary ingredient. It is on those crops that gypsum is found to be most efficacious.

Having now made you acquainted with the various modes of improving the soil, we are next to consider which are the best means of supplying plants with food.

Caroline. All natural soils, with the exception, perhaps, of burning sands, or arid rocks, must contain nourishment for plants; otherwise they would not grow spontaneously as they do in wild, uncultivated countries, which often abound with forests and rich pastures.

Mrs. B. True; but though this supply be sufficient for a natural state of vegetation, when the land is forced, as it were, by agriculture to yield food for man, a greater produce must be obtained; and we cannot raise those rich and numerous crops, so necessary to the existence of a civilised country, without affording the vegetable creation an artificial supply of nourishment: for it is an axiom, no less true in the vegetable than in the animal kingdom, that food must be proportioned to the population, in order to maintain it. The mode which art has devised to increase the quantity of food for plants is to spread manure on the soil. Manure consists of the remains of organised bodies of every description, whether animal or vegetable, in a state of decomposition; that is to say, resolving itself into those primitive elements which can re-enter into the vegetable system.

Caroline. The preparation of food for plants is then precisely the inverse of that for animals, or at least for animals of the human species. Our culinary art consists in mixing and combining together a variety of ingredients to gratify the palate; whilst bodies must be decomposed and resolved into their simplest elements to suit the vegetable taste.—And how is this process performed?

908.—When and how should it be used? 909.—What is said of clover and saintform in connection with gypsum? 910. When do soils require artificial nourishment? 911.—How is it imparted? 912.—Of what does manure consist?

Mrs. B. I have explained it to you in our Conversations on Chemistry: it is by the last stage of fermentation —*putrefaction.* Loathsome as this term may appear to you, yet, when you consider it as the means which Nature employs to renovate existence, and continue the circle of creation, you will view it with admiration rather than with disgust.

Emily. It is very true; the operations of Nature, when philosophically contemplated, are always admirable: those elementary substances, which, in their simple state would be disagreeable to us, by passing into the vegetable system, are converted into the most palatable and nutritious food. When in the resources of Nature we discover such evident proofs of the goodness of the Creator, the philosopher may well exclaim with the poet:—

> "These are thy glorious works, Parent of good,
> Almighty! Thine this universal frame
> Thus wondrous fair; thyself how wondrous then!
> Unspeakable! who sit'st above these heavens
> To us invisible, or dimly seen
> In these thy lowest works; yet these declare
> Thy goodness beyond thought, and power divine."

Mrs. B. This beautiful burst of praise, into which Adam breaks out on the creation at large, is no less applicable to the wisdom and prudence displayed in the arrangement and distribution of its minutest parts.

The principal result of the decomposition, whether of animal or vegetable matter, is carbonic acid; and in this state carbon, which we have called the daily bread of plants, finds entrance at their roots.

Caroline. But it is not enough to introduce carbonic acid at one extremity of the plant: you must get rid of the oxygen at the other extremity before the plant can feed upon its daily bread.

Emily. This, you may recollect, is performed by the leaves when exposed to light and air.

Mrs. B. Manure acts on dry soils also as *amendement* by retaining moisture. Manure which has not completely

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913.—What is said of putrefaction as a means of preparing bodies for nourishment for vegetables? 914.—What does Emily say of the operations of nature? 915.—What is the quotation she makes from Milton? 916.—What is the principal result of decomposition? 917.—How do manures affect dry soils?

undergone the process of fermentation, so that the straw is not yet wholly decomposed, is best adapted to strong compact soils: the tubular remnants of straw answer the purpose of so many little props to support the earth, and afford a passage for the air, thus rendering the soil lighter; besides, the completion of the fermentation taking place after the manure is buried in the soil, has the advantage of raising its temperature.

Emily. Since the putrid fermentation reduces every animal and vegetable substance into its primitive elements, there are none, I suppose, which may not be converted into manure?

Mrs. B. None; but some bodies are more readily decomposed than others: it is from domestic animals that the best manure is obtained. In maritime districts, fish, when sufficiently abundant, is sometimes used to manure the land. They are easily decomposed, and afford a considerable quantity of nourishment. Even such hard substances as horn, hair, feathers, and bones, are all resolvable into their primitive elements, and make excellent manure; but, owing to their dry nature, require a longer period for their decomposition. Such substances are calculated not for annual harvests, but to fructify the soil for a produce of much longer duration, such as that of olive-trees and of vineyards.

Vegetable manure does not always undergo fermentation previous to being buried in the soil: green crops, such as lupins and buck-wheat, are sometimes ploughed in, and thus buried for the sole purpose of enriching the soil. A green crop contains a considerable quantity of water; and the plants, when buried, serve to lighten the soil previous to decomposition, and subsequently to enrich it with food for the following crop. This species of living manure is particularly calculated for hot countries, on account of the abundance of moisture it incorporates with the soil.

Emily. I have seen sea-weeds used as manure, which has at least the advantage of being a gratuitous crop.

Mrs. B. Gratuitous in some respects, but requiring a

918.—When manures perform a part of their fermentation buried in the soil, what is the consequence? 919.—What are the best manures? 920.—What is said of horns, hair, feathers, and bones for manure, and for what are they suited? 921.—And of buckwheat and lupins? 922.—And of green crops buried in the soil? 923.—For what countries is this species of manure particularly calculated?

difficult and laborious carriage. The Isle of Thanet owes its reputation in a great measure to the power of procurring this manure. And the sea-salt they contain is also favorable to vegetation. Straw is an excellent ingredient for manure; but it requires being mixed with animal manure, or stratified with earthy matter. Bark and sawdust are occasionally used for manure: they should, however, with greater propriety be considered as materials for improving the soil, as they afford but little nourishment.

The grain which produces oil, such as linseed, rapeseed, &c., makes excellent manure after the oil has been expressed: in this state it is called oil-cake, and its unctuous qualities serve to accelerate decomposition; but in England it sells at such a price as to make it a doubtful speculation even to feed cattle with. It would be too expensive to be used as manure.

Emily. Pray, would not soot make very good manure? It is almost pure carbon, in so highly a pulverised state, as must render it fit to enter into the vegetable system.

Mrs. B. You forget that it is first necessary to combine it with oxygen; and this is a work of time. Soot has, however, an immediate beneficial effect, though not a very permanent one: it is used in large quantities in Hertfordshire, both for grain and pasture, and is strewed on the land in March and April, for the crop of the same year.

Caroline. I recollect having observed that the environs of the spots, where charcoal has been prepared in the mountains, are absolutely destitute of vegetation, although strewed with charcoal-powder.

Mrs. B. But were you to visit these same spots some few years afterwards, you would find vegetation more flourishing, more vigorous, and especially greener than elsewhere, because the charcoal-powder will have gradually combined with the oxygen of the atmosphere, and thus vegetation be luxuriously supplied with its favorite food, carbonic acid.

The most common manure consists of a mixture of animal and vegetable materials; and this, again, is frequently stratified with mineral substances, such as mud from

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924.—What is said of sea-weed used as manure? **925.**—And of bark and sawdust? **926.**—What grains are good for manures? **927.**—What is said of oil cake? **928.**—What is said of soot, as a manure—in Hertfordshire? **929.**—What is seen to take place, where charcoal is prepared? **930.**—Of what does the most common manure consist?

the streets, dust from the roads, or earth of different descriptions, the whole forming a rich compost. Mud from the beds of rivers, when it can be obtained, is a very valuable ingredient for such a compound, as it abounds with organic remains of fish, shells, reptiles, and rotten plants. Often, however, before being laid upon land, it requires being well turned up and exposed to the air for some time.

Caroline. It is to be regretted that such precious relics should, in general, be lost by being carried by the current of the river into the sea; but the slime of ponds and all stagnant waters must make very rich manure.

Mrs. B. Yes; they may be considered as storehouses of materials, ready to return into the vegetable system.

The elevation of temperature produced by the completion of fermentation of the manure, after it is mixed with the soil, is but inconsiderable, excepting in garden culture, where, accumulated in hotbeds, it often produces a temperature equal to that kept up in a hothouse.

Short manure, that is to say, that which is thoroughly decomposed, and in which the water and other evaporable parts have in a great measure disappeared, contains a considerable quantity of carbon.

Long manure, in which state fermentation is but little advanced, contains a greater proportion of water: the first is, therefore, best adapted to moist, the latter to dry, soils.

Emily. But if the fermentation be completed previous to mixing the manure with the soil, are there not many volatile products which escape into the atmosphere, and which might, if buried in the earth, have promoted vegetation?

Mrs. B. No doubt. It is incalculable how many valuable materials are "wasted on the desert air" which should have given vigor to vegetation; others are dissolved by moisture, and drained off by rain; but these liquifactions are generally collected and turned to account. To prevent, as far as possible, such losses, dunghills should be sheltered from the atmosphere by sheds: these should, however, remain open on the sides, as air in a moderate quantity is required to promote fermentation.

931.—What is said of mud in the beds of rivers? **932.**—And of the elevation of temperature produced by the completion of fermentation? **933.**—Of short manure? **934.**—Of long manure? **935.**—Why should dunghills be sheltered? **936.**—Why should the sheds be open at the sides?

Emily. In which state do you consider it most advantageous to bury manure in the soil: when the fermentation is only partially, or when it is completely effected?

Caroline. I should suppose in the former state, in order to prevent the loss by evaporation. When the fermentation goes on in the soil, the elastic as well as the liquid and solid parts are retained; then the act of fermentation raises the temperature.

Mrs. B. One state is better for some species of crops, and the opposite for others. The only disadvantage attached to long manure is, that it requires a greater length of time to convert it into nourishment for plants.

Short manure is a meal already cooked, and ready for the crop to feed on; if, therefore, the crop requires very prompt sustenance, the former must be used; if not, the latter is in every respect preferable: it is particularly adapted to stiff soils, the straw, previous to its decomposition, rendering it lighter.

Emily. It is evident that it must be advantageous to bury either descriptions of manure as soon as it is spread on the soil, to prevent loss by evaporation; but how deep should it be laid in the soil?

Mrs. B. That depends upon the nature of the culture; for the manure should be as much as possible within reach of the roots. For this purpose, it should not be buried quite so deep as the extremity of the roots; for, in proportion as it is dissolved and liquefied, it will naturally descend. Due allowance must be made for this; for, if any part subside below the roots of the plants, it is utterly lost, at least for that crop.

Emily. It is then, I suppose, better to manure the land in the spring than in autumn, lest the winter-rains should dissolve it too much, and endanger its sinking below the roots of the crop.

Mrs. B. That is the prevailing opinion of agriculturists. With regard to the quantity of manure, it is a commodity so scarce, that it is not likely to be employed in excess. This occurs, however, sometimes in garden culture, and it produces a strong and disagreeable flavor in

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937.—Is it best to bury manure in the soil, when fermentation is completed, or when only partially effected? 938.—What is said of the depth at which manure should be buried? 939.—Why is it thought better to manure land in spring than autumn? 940.—What is the consequence if manure is used in too great quantities?

the vegetables; even the cows avoid the strong coarse grass which grows on spots they have manured too abundantly. But the stock of manure is generally so limited, that it has been the study of agriculturists to discover some means of compensation for a deficiency, rather than to apprehend danger from excess. This compensation has been found in a judicious system of crops; but it is too late to enter upon a new subject to-day, and one of so extensive a nature well deserves to have a morning dedicated to its consideration.

CONVERSATION XIV.

THE ACTION OF SOIL ON PLANTS CONTINUED.—ROTATION OF CROPS.

Mrs. B. It has long been observed, that two successive harvests of the same species of plants, or even of plants of the same family, do not succeed: the second appears to degenerate, as if the first had been injurious to it.

Caroline. The first crop had no doubt exhausted the soil of nutriment.

Mrs. B. In the infancy of agriculture, when land was plentiful, because inhabitants were scarce, this was easily remedied by cultivating only a certain portion of land, and, after having exhausted it, transferring the cultivation to another part, and thus successively bringing new land into tillage, till, after a series of years, they return to the spot which had been previously cultivated. This mode, called *ecobauge*, was first introduced by the Celts, and may still be traced among some of their descendants in Brittany. They usually commenced their operations by burning the natural produce of the soil before they ploughed it. If the soil was stiff and argillaceous, the ashes resulting from this combustion seemed to ameliorate it, by increasing the stock of carbon, of sand, and of salts; but if light, such a proceeding was not judicious.

The system of fallows, which we derive from the Romans, is an improvement on that of the Celts; the soil is

941.—What has long been observed? 942.—In the infancy of agriculture how was this remedied? 943.—What was this mode called, and by whom was it introduced into Britain? 944.—How did they commence operations, and what was the result? 945.—What is the system of fallows, and from whom was it derived?

allowed only one year's repose occasionally, and during that season it is repeatedly turned over by the plough; every part is thus exposed to the atmosphere, whence it absorbs oxygen, and the weeds, being buried by the plough, serve to enrich, instead of exhausting, the land.

The system of *assolemens* we owe to those excellent farmers the Belgians. It is of two descriptions: the first consists in the judicious cultivation of such a succession of crops, that they shall derive benefit instead of injury from each other; the second is that of raising two crops simultaneously, which shall mutually benefit each other. As we have no precise term to express these processes, I shall take the liberty of using the French word *assolement*.

Those of the first description, which our farmers denominate a rotation or course of cropping, is particularly adapted to northern climates.

Emily. And of what description are the crops which ought to be cultivated in rotation?

Mrs. B. Before this point can be determined, we must endeavor to solve the problem why one crop is prejudicial to another of the same family; why two sorts of grain cannot be raised in succession without the latter degenerating; whilst leguminous plants succeeding a crop of grain are improved by it.

Emily. I thought that the first crop, especially if one of grain, which requires so much nourishment, would injure the soil for any succeeding crop by exhausting it of nutritive particles.

Caroline. But since it appears that leguminous plants can follow grain with advantage, it seems evident that these two crops must feed upon different kinds of nourishment, and thus the one will not interfere with the other.

Emily. You forget, Caroline, that plants cannot select their food, but suck up whatever comes within reach of their roots, and is sufficiently minute to find entrance there. All plants must, therefore, feed upon the same nutritive particles.

Caroline. Then I will suggest another explanation. Perhaps the roots of plants which succeed each other without injury may be of different lengths, and one crop

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946.—What is the system of assolems? 947.—For what climates is rotation of crops particularly adapted? 948.—What does Mrs. B. say must be ascertained before stating what description of crops should be cultivated in rotation? 949.—How does Caroline think this problem may be solved?

seek its nourishment near the surface, while the other penetrates deeper into the soil; thus they would both be fed without interfering with each other.

Emily. But you do not consider, Caroline, that the plough overturns your theory, in overturning the soil; for it brings the lower part to the surface, and mixes the whole so well together that the nutritive particles must be pretty equally diffused throughout.

Mrs. B. Your observation is very just; and we find that clover, which has very superficial roots, will not thrive after lucern, whose roots are very long. This theory, however, is applicable to simultaneous crops whose roots are of different lengths. Another theory has been suggested, which is, that the fall of the leaf of the first crop fertilises the earth for a second: this is undoubtedly true to a certain extent; but the foliage can fertilise the earth only by being converted into manure, which would equally afford nourishment for a second crop of the same nature.

Caroline. Nay; one would even suppose that a green crop, ploughed into the soil, would afford more appropriate food for a second crop of the same description than for one of a different family; that the leaves of straw would yield the best nutriment for a future crop of corn, and of grass for that of grasses; whilst the fact, you say, is exactly the reverse.

Mrs. B. The theory which M. De Candolle is most inclined to favor, if indeed he is not its author, is the following. A plant, being under the necessity of absorbing whatever presents itself to its roots, necessarily sucks up some particles which are not adapted to its nourishment, and in consequence,—after having elaborated the sap in its leaves, and re-conducted it downwards through all its organs, each of which takes in the nourishment it requires; after having extracted from it the various peculiar juices, and in a word, turned it in every possible way to account,—finds itself encumbered with a certain residue, consisting of the particles it had unavoidably ab-

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950.—How does she think the different lengths of the roots may operate in doing it? 951.—How does Emily reply to Caroline? 952.—What does Mrs. B. say of clover and lucern in illustration of the subject? 953.—What other theory has been suggested of fertilization from the leaves? 954.—What does Caroline say of this? 955.—What is the theory of Candolle?

sorbed, and which were not adapted to its nourishment, these particles, having passed through the system without alteration, are exuded by the roots which had absorbed them, and thus return into the soil, which they deteriorate for a following crop of the same species of plant, but improve and fructify for one of another family; thus affording an admirable proof of the wise economy of Nature, in multiplying her vegetable produce by feeding different plants with different substances, and enabling beings, incapable of distinguishing or selecting their food, to obtain that which is appropriate to them.

Emily. It is, indeed, admirable! Then, though the roots of plants can make no choice, their organs are in some measure capable of selecting, since they reject, and will not elaborate, substances which are not adapted to the nourishment of the plant.

Mrs. B. If we cannot exactly allow them the nice discrimination of the chemist, we must at least suppose their laboratory to be so arranged as to act only on bodies congenial to the plant.

Caroline. And the rejected substances, which would be poison to one family of plants, when transfused into the soil, is greedily devoured by a succeeding crop of a different family.

Emily. Yet, Mrs. B., there is land in the Vale of Glastonbury, in Somersetshire, which is celebrated for growing wheat for many years together without any manure; and I have heard that in the neighborhood of the Carron iron-works, in Scotland wheat has been raised above thirty years, without injury either to the crops or the soil.

Mrs. B. Those soils must not only abound with vegetable nourishment, but the land be particularly well adapted to growing wheat; consequently the roots would have little or nothing to exude, and successive crops of wheat might be raised so long as the land was not exhausted. This explanation would reconcile your difficulty to the theory of exudations; but, interesting and plausible as this theory is, it requires the confirmation of facts to rest on a solid foundation: few experiments have

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956.—What in this theory affords admirable proof of the wise economy of nature? **957.**—What cases are mentioned by Emily of the growing of wheat? **958.**—How does Mrs. B. account for them?

yet been made relative to it. Mr. Brookman has raised some plants in sand, and ascertained that they exuded by the roots small drops during the night, which there is reason to suppose was the object in research; but experiment has not yet been pushed far enough fully to verify it.

Caroline. It appears to me to explain the theory of *assolement* so well, Mrs. B., that I feel strongly inclined to put my faith in it. How perfectly it accounts for the advantages derived from cultivating leguminous and graminiferous crops in succession, the exudations of the one being exactly the nutriment which the other requires.

Mrs. B. I am so much inclined to agree with you in opinion, that I shall venture to draw conclusions from it, as if the theory were established; cautioning you, however, to bear in mind, that until it has been further investigated, it must be considered as little more than hypothetical.

You must besides remember that it is manure which affords the grand store of provisions equally good for plants of every description. If, in addition to the exudations of leguminous plants, you plough in the crop itself, the succeeding crop of corn will be considerably improved.

Emily. Supposing you were to plough in a crop of young rye, could you not the following year sow wheat with advantage? for the rye would have had but little time to deteriorate the soil by its exudations, and afford much manure by the fermentation of its own substance.

Mrs. B. I do not know that the trial has ever been made; but it would certainly succeed better than if you were to reap the rye when ripe, and afterwards sow wheat: for, in this case, the rye would have given to the soil the whole of its exudation, and little or none of its own substance.

Caroline. May it not be objected to this theory that Nature does not raise plants of different families in succesion? The seeds of the parent-plant fall to the ground annually, and produce other individuals of the same species, and on the same spot, for centuries; and yet that spot must be

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959.—What was done by Mr. Brookman? 960.—For what does Caroline say it will account? 961.—Of what does Mrs. B. caution Caroline? 962.—What does she tell her must be remembered? 963.—What answer is given to the question—If a crop of young rye were ploughed in, what would be the effect upon the growth of wheat the following year? 964.—What question does Caroline then ask on the same subject, and what illustration of her meaning does she give?

vitiated for such plants by the long series of exudations of their progenitors.

Mrs. B. If Nature does not usually employ successive, she does simultaneous *assolements.* In her spontaneous forests she raises such a prodigious variety of trees and shrubs, and in her meadows such a multiplicity of herbs and grasses, that the different plants mutually supply each other with exudations.

Emily. Besides, where Nature acts without restraint, she enriches the soil not only by the annual fall of the leaf, but, in the course of time, the whole plant, whether grass, shrub, or tree, returns to the soil, to repay the nourishment it had received during its life.

Mrs. B. The soil can never be impoverished by natural vegetation : that of forests, where man does not cut down and carry away the trees, is not more exhausted of nutriment at the present day than it was a thousand years ago.

Those magnificent forests which covered the face of the greater part of America, when it was first known to us, never had any other manure than the remains which its vegetable and animal productions afforded ; nor can a better be supplied. And we in some respects copy Nature when we prepare the soil for corn by ploughing in, a green crop of leguminous plants.

There is nothing which exhausts either a plant or the soil in which it grows, so much as the ripening of its seeds. No animal labors with greater effort to support its offspring than the poor plant to bring its seed to maturity : it pumps up sap with all its powers of suction ; yet, if it has much seed to ripen, after having accomplished its task, it frequently perishes through exhaustion from the intensity of its efforts.

Perennial plants have but few, and but small grains to ripen, while those of annuals, are large and much more abundant ; and it is this difference, perhaps, which constitutes the real distinction between these two classes of plants : the one, exhausted by its efforts, dies after ripen-

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965.—What does Mrs. B. say in reply of assolements? 966.—By natural vegetation what effect is produced on the soil? 967.—Of the forests of America what is said? 968.—What is most exhausting to the plant and the soil? 969.—What constitutes the principal difference between perennial plants and annuals?

ing its seed ; whilst the other having a less laborious task to perform, lives through several successive years.

Caroline. If that is the only distinction, an annual might live several years, were its seed prevented ripening.

Mrs. B. Instances of this sometimes occur in cold countries, such as Scotland. If the season has not afforded sufficient heat to ripen the corn, and that the following winter has not been so severe as to prove fatal to it, it will ripen the succeeding summer ; and, indeed, whenever by any artificial means you prevent the ripening of the seed of an annual, it becomes perennial.

But to return to our subject. The succession of crops should be so arranged as to prevent as much as possible the growth of weeds : but what plant is it which deserves so opprobrious a title ? for not one issues from the hands of its Creator which is not destined to act some useful part in its own sphere : either its exhalations purify the air ; its exudations fructify the earth ; its fruit supplies us with food or clothing ; its blossoms regale our senses ; and even its poisons minister to our diseases. What plant can we then denominate a weed ?—The only blame which attaches to weeds is (as Dr. Johnson expresses it) being out of their place ; and it is the business of the agriculturist so to fill up the place they would occupy, as to drive them out of the field. This cannot be more effectually accomplished than by the cultivation of artificial grasses, such as clover and lucern, which, when sown thick, produce a shade very prejudicial to the growth of weeds ; if sown thin, so as to leave space, light, and air, it, on the contrary, encourages their growth.

There is nothing more favorable to the improvement of land than hoed crops, provided no immediate profit be expected from them, and that we are satisfied if they repay the expenses of cultivation ; that is to say, the value of the seed, the hoeing, the ploughing, and the manure.

Emily. But why are not these crops sown so thick as to prevent the growth of weeds, and, consequently, the necessity of hoeing ?

970.—How might an annual be mude to live several years, and where has it been done? 971.—How should the succession of crops be arranged? 972.—What does Mrs. B. say of weeds? 973.—What does Dr. Johnson say of them? 974.—How can the evil named by him be remedied? 975.—What is the effect of hoed crops on land?

Mrs. B. These crops consist of plants whose roots require a great deal of nourishment, such as peas, beans, turnips, potatoes, and carrots; and, if sown thick, the soil would not afford a sufficient supply.

Emily. Yet the weeds which spring up between these plants must rob the soil of a part of its nourishment.

Mrs. B. They do so, but only temporarily; for the dead weeds, after hoeing, return to the soil in the form of manure. The advantage of hoeing is not confined to the destruction of weeds: it loosens the earth so as to admit the air, turns it over, and heaps it around the roots of the plants cultivated.

As hoed crops stand in need of a great deal of manure, they should precede grain, which also requires manure to ripen the seed; and it is from the sale of grain, raised under these advantageous circumstances, that the cultivator will derive his profit.

It must be recollected, also, that the more the green crops are increased, the greater is the number of cattle you are enabled to feed, and, therefore, the more considerable is the stock of manure. It is very remarkable, and, however paradoxical it may appear, is nevertheless true; that, since the introduction of *assolements,* meadows diminish whilst cattle increase, and corn-fields diminish whilst grain increases. These miracles are performed by the artificial grasses, and the leguminous and other green crops, which not only prepare the earth for grain by their exudations, but enrich it by their remains; which leave no space for weeds, and supply abundant food for cattle.

Caroline. And what is reckoned to be the due proportion of corn to meadow land in a farm?

Mrs. B. The distribution of a farm should be so arranged that the several portions should mutually contribute to each other's advantage. The farmer should aim at raising every year the same quantity of produce; for though it is true that the vicissitudes of seasons render

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976.—Why are not these crops sown so thick as to prevent the growth of weeds? **977.**—What prevents weeds springing up between the plants of these crops from impoverishing the ground? **978.**—Why should hoed crops precede grain? **979.**—What fact relating to this subject seems paradoxical? **980.**—How are these miracles as they are called performed? **981.**—How should the distribution of a farm be made? **982.**—What should the farmer aim at raising?

this end unattainable, yet, by keeping it in view, you will the more nearly approximate to it.

When once the land is laid out to feed the number of cattle required for the work of a farm, and to produce the manure necessary for the soil, no change can take place without disadvantage. If you augment the produce of grain, it must be at the expense of the leguminous crops: the cattle will suffer for want of forage, and the soil from deficiency of manure.

Emily. And even the corn of the following year will degenerate for want of that preparation of the soil produced by leguminous crops.

Mrs. B. The Belgians, whom we consider as among the best farmers, lay out their lands so as to obtain, as far as possible, equal results annually. They derive their profit from the sale of their corn : this alone goes to market, the forage being all consumed by the farming cattle, and the manure employed on the soil. A Belgic farm consists of generally from thirty to forty acres : the succession of crops is strictly regular, and comprehends a period extending from ten to fifteen years.

In rural economy an intervening crop is occasionally raised between two regular crops ; thus, buck-wheat is often sown in that country as soon as the land can be ploughed after wheat, and is gathered in late in the autumn ; but a double crop of grain is very exhausting to the soil, and it would be better that these stolen intermediate crops should be of leguminous plants. In England we do not attempt them : our corn is got in too late to admit of sowing for a second produce the same season.

Emily. What a prodigious advantage a rotation of crops has over fallows ! If leguminous crops do not yield any profit, they defray at least all the expenses of their cultivation, and prepare the soil for a rich harvest of grain ; whilst a fallow affords no crop whatever to repay the expense of ploughing and manuring, and does not so well prepare the soil for grain.

Mrs. B. The greater the variety of crops raised in a country, the more we consider that country as advanced

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983.—What is said of the number of cattle when the land is laid out to feed? **984.**—And of the Belgian farmers? **985.**—How large are their farms? **986.**—What are intervening crops? **987.**—What is their effect on the soil? **988.**—What connection is there between variety of crops and knowledge of agriculture?

in the knowledge of agriculture, for every new plant affords security against sterility; and the more crops are diversified, the smaller are the chances of suffering from the inclemencies of the season, for what is injurious to the one may be salubrious, or at least not detrimental, to the others. It affords also a surer market; for every species of produce will not fall in price at the same time, and thus the chances of loss are diminished. It is also an essential point, so to distribute the labor of a farm, that every operation may be made at the most suitable period.

Emily. The course of cropping must admit of modification, according to the locality, or the greater demand, for any one species of produce.

Mrs. B. Certainly; in England, for instance, where the beverage of the common people is beer, a greater quantity of barley and hops must be raised than in wine countries. Then the moisture of the English climate admits of our raising very abundant crops of turnips, peas, and beans: these plants enter with great advantage into our course of crops.

Caroline. The vicinity of great towns must also influence the nature of the crops: it will be necessary to supply their markets not only with food but also with bulky produce, the carriage of which is expensive; such, for instance, as hay, a very great quantity of which is required to maintain the stock of horses and milch cows of a large town, which are quite independent of a farm.

Mrs. B. So far as regards their laboring for a farm, it is true; but the land profits by their manure: it is in order to supply hay for these animals that you generally see large towns surrounded by grass land. The oxen and sheep destined for food are brought from more distant parts, as they carry themselves to market almost free of expense.

The culture of the vine, especially in temperate climates, where this plant requires a great quantity of manure, necessarily modifies the *assolement;* for the farm must be so

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989.—And between variety of crops and a good market? 990.—Why are barley and hops raised in England? 991.—And turnips, peas, and beans? 992.—What influence does Caroline say great towns have on the nature of crops? 993.—Why are large towns surrounded with grass land? 994.—What effect does the culture of the vine have on assolement?

distributed as not only to afford manure for the succession of crops, but a large surplus for the vineyard.

Emily. This must be difficult to accomplish without making the general culture suffer from such a considerable subtraction; and, indeed, I have observed, that in Switzerland every thing seems to be sacrificed to the culture of the vineyard, as being that portion of the farm which affords the greatest profits.

Mrs. B. And which also occasionally produces the greatest losses. It may be considered as a game in which the highest stake is pledged; the greatest pains are therefore taken to increase the chances of winning.

The nature of the soil must also modify ***assolements.*** The light soils of Belgium and Alsace are very favorable to this system, while stiff tenacious soils offer considerable difficulties: they are, however, well worth the trouble of surmounting, as this mode of culture diminishes the quantity of manual labor, which such ungrateful soils require, and which renders their cultivation so expensive.

Emily. And what is the most eligible succession of crops?

Mrs. B. The most common is an *assolement* of only four years; the first of which is a hoed crop to destroy weeds: turnips, potatoes, beet-root, carrots, or any other plants with long roots, are very appropriate for this purpose, as it obliges the farmer to plough deep, in order to prepare the soil for them. After gathering in this crop, the leaves and remnants of the plants are ploughed into the soil, the land is manured, and wheat and clover are sown together.

The clover does not make its appearance till after the corn is reaped. Little advantage is made of the produce of clover the first season, but the following year it yields an abundant harvest. After having mowed it, the ground is ploughed, and the remains of the clover buried; and thus, both by exudations, and by a part of its own substance, it renovates the soil after the exhaustion it had undergone in ripening the corn, and enables it to produce

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995.—What does Mrs. B. say of the profits of the vine? 996.—What soils are favorable and what ones unfavorable for it? 997.—What effect does assolement have on the amount of labor needed in agriculture? 998.—What is the most common assolement, and how is it described? 999.—What is said of the growth of clover?

a second crop of grain the fourth year, which completes the *assolement*.

The rotation of crops must, however, necessarily vary with the soil: that which I have described, from M. De Candolle, is probably best adapted to France; in England turnips, I believe, are usually followed by barley, clover, and wheat.

Caroline. Pray, why should not trees require an *assolement* as well as corn and leguminous plants? for the exudations of a tree during the number of years it lives must greatly injure the soil for another of the same kind. —Nay, I wonder how the same individual tree can thrive throughout a long life in a soil so deteriorated.

Mrs. B. You must consider, in the first place, that the roots of a young tree are of small extent, and both seek their food and give out their exudations in the ground immediately surrounding the stem. In proportion as they lengthen they extend their researches, spreading wider and piercing deeper into the soil; thus, after having exhausted it of nourishment, and deteriorated it near the stem, they find fresh aliment in a more enlarged sphere.

Emily. Then when a tree dies, if another of the same kind be planted in its place, the young roots will find the soil near the stem exhausted of nutritive particles, and vitiated by exudations? and yet, when a dead tree in an avenue is replaced by another of the same species it grows without difficulty.

Mrs. B. If you replaced it by one of another family, there is no doubt but that it would thrive better. One of the same species is, however, not without resources; for you must consider that the soil nearest the stem of the old dead tree has not been acted upon by the roots for a number of years; and, during this period of repose, it has been able, in a great measure, both to renovate its nutritive particles by the natural manure it receives annually from the fall of the leaf, and to purify itself from exudations of the old tree, these being absorbed by the grasses, underwood, and plants of various descriptions which sur-

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1000.—How does assolement differ in England from what it is in France? 1001.—Why should not trees as well as corn and leguminous plants require an assolement? 1002.—When a tree dies will another of the same kind grow in the same place? 1003.—Why did not the soil suited to its nourishment be completely exhausted by supporting the first?

rounded the tree, and which, in return, supply the soil with exudations adapted to forest trees: these ameliorations will enable a second tree to live and grow upon the same spot as its progenitor, though certainly not with the same vigor as if it were of a different family.

Caroline. In replacing a tree in an avenue we are not at liberty to choose its species; but in our gardens it is surely wrong to replace an old fruit-tree by another of the same species.

Mrs. B. This is not so easily obviated as you imagine; for it is not sufficient to change the species: you must change the family; and almost all our fruit trees are of the same family. To remedy this inconvenience, the gardener must supply the young tree with fresh soil, which in a great measure answers the same purpose. This new earth should, if possible, be brought from the neighborhood of forest-trees, which are of another family. Manure may at the same time be introduced. Nursery gardeners alternate plantations of fruit and of forest-trees.

Caroline. When a wood is cut down another springs up of the same trees, shooting up from the old roots, or germinating from the seeds naturally sown. Yet how can these young plants find sustenance in a soil both exhausted and vitiated by the parent-trees?

Mrs. B. You assume as a fact what is only a natural inference. If, when a natural forest be cut down, a second springs up, it will consist of trees of another family; a forest of oaks, for instance, may be succeeded by one of aspen, which is of a different family, or the oaks may be replaced by some species of fruit-trees.

Caroline. I am not talking of replanting the forest, but of that which would naturally spring up were the first cut down. Now we know that aspen and fruit-trees will not germinate from acorns.

Mrs. B. It is the acorns which will not germinate in a soil so ill prepared for them; whilst the seed of the aspen, or kernels of fruit-trees, which may chance to be here and

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1004.—Will it grow with the same vigor, as if it were of a different family? **1005.**—What comparison is made by Caroline between replacing trees in an avenue and a garden? **1006.**—How does Mrs. B. reply to her? **1007.**—What does she say of supplying it with new earth? **1008.**—What inquiry does Caroline make respecting a wood that is cut down? **1009.**—How does Mrs. B. reply to her? **1010.**—What is said of the germination of the acorn and the seed of the aspen?

there intermixed with the oaks, will find a soil so well adapted to them that they will germinate readily and grow rapidly. Thus a wood of aspen and fruit-trees will succeed to one of oaks; but, after a long course of years, the old stumps and roots of oak, favored by the exudations of the forest of a different family, will shoot out, and, in the end, supplant the new forest, and a second forest of oaks will be re-established, but not till after an *assolement* of trees of another family. You see, therefore, that Nature occasionally makes successive as well as simultaneous *assolements.*

Caroline. This is very curious. I did not conceive it possible for an *assolement* to take place where industry did not interfere with the natural course of vegetation. But this succession of crops must change once a century rather than once a year.

Mrs. B. They are doubtless of very long duration. The *assolements* of trees which occur in the course of agriculture are of a more transitory nature: they are generally made with a view to improve new soil, in order to prepare it for cultivation, such as the simultaneous *assolement* of broom and pines in the Campine of Belgium. These shrubs enrich the soil for the future cultivation of grain, both by their exudations and by the manure formed from their leaves.

I have seen a very singular *assolement* in the neighborhood of the Rhine, consisting of alternations of vine and clover. After a period of twelve years the vines are grubbed up, and clover sown for three or four years.

But the most remarkable *assolement* is that of water. There are some districts in France in which the low grounds are laid under water for the period of a twelvemonth, and this is renewed every seven years.

Caroline. What harvest can be obtained from such a culture, unless it be fish?

Mrs. B. Fish and wild fowl form, in fact, the only produce while the land is under water. This mode of culture

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1011.—How is the establishment of a second forest of oaks described? 1012.—What is seen from this? 1013.—What is said of the duration of the assolement of trees? 1014.—With what view are they made? 1015.—What singular assolement has Mrs. B. seen in the neighborhood of the Rhine? 1016.—What more remarkable one is named? 1017.—What advantage has it?

has the advantage of draining the surrounding country, and of favoring the production of aquatic plants, which afford food for a prodigious quantity of worms and insects. All these productions, whether animal or vegetable, leave their relics at the bottom of the sheet of water; and, when it is drawn off, the land remains covered with an abundant stock of the richest manure. There are many ponds of this description in the country of Bresse in the Lyonis. If the water with which these parts abound were more generally diffused, they would become marshy and unwholesome; for it is the scum of superficial stagnant waters which is deleterious, not the evaporation of deep waters. On the other hand, were these ponds permanent, their disposition of rich manure would either be lost, or could be drawn out only at a great expense; whilst, if you change the locality of these ponds, by drawing off the water to another spot, the manure remains ready spread on the soil, and the farmer has only to plough it in and sow his seed. The water in the mean time occupies another low land, where, in its turn, it accumulates and deposites its riches: with the assistance of locks, it is thus made to perambulate through the valleys and low lands. Great care is taken to preserve the young fish, and transfer them to their new basins; for these, like the sheep of the meadow, not only supply us with food, but enrich the soil for future vegetable produce.

I was once present at the operation of drawing off a sheet of water, of no less than seven hundred acres in extent. It was in the month of October. During the preceding summer, fish had been caught and wild fowl killed in prodigious abundance; but when the secrets of the prison-house were exposed to view, it afforded a very curious spectacle. The markets of all the neighborhood were supplied with full grown fish; the young fry were sold to stock other ponds; and rich and ample were the remnants of animal and vegetable manure which prepared the ground for culture the following season.

Simultaneous *assolements* are as advantageous to warm countries as successive *assolements* are in our northern cli-

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1018.—Where are many ponds of this description? 1019.—Under what circumstances would they become unwholesome, and when would the manure furnished by them be lost? 1020.—How is the locality of these ponds sometimes changed? 1021.—What account does Mrs. B. give of one of these operations?

mates. The circumstance chiefly to be attended to in this mode of culture is, that the two crops should seek their nourishment at different depths; thus the vine and corn may be raised together, the roots of the vine being much longer than those of corn.

Emily. In Italy we have seen them continually accompanying each other: strips of corn separating the rows of vines trained on trees; which latter also compose a part of the *assolement.*

Mrs. B. The vine is sometimes twined round the olive, whose roots strike still deeper into the earth. For the same reason, the peach and the almond are often raised in vineyards; while apple and pear trees would not thrive, because their roots are as superficial and as spreading as those of the vine.

Caroline. Their shade might also be prejudicial, while the foliage of the peach and the almond is comparatively light.

Mrs. B. The degree of shade must be regulated by that of the temperature of the climate. In hot countries leguminous plants succeed well interspersed with trees, because their shade, by diminishing evaporation, retains moisture in the soil. Thus corn thrives intermixed with turnips and clover: the two latter, when young, requiring the shade which the corn affords; and after it is reaped, the sun is necessary to ripen them.

Wheat and rye are sometimes sown promiscuously: it is an old custom, and, I believe, a very bad one; both plants being of the same family, their exudations are noxious instead of advantageous to each other. Then they do not ripen at the same period; so that when reaped, the one must be over-ripe, or the other not come to maturity. If the intent be to make bread of these two species of corn, it would be preferable to mix the grain after the harvest; indeed, it would be best to keep them separate till after grinding, for, not being of equal size and hardness, a loss is also experienced in grinding them together.

Caroline. It is customary, also, in sowing grasses for forage to mix a great variety together.

1022.—What circumstance should be chiefly attended to in simultaneous assolements? 1023.—What ones has Emily seen in Italy? 1024.—What other ones does Mrs. B. mention? 1025.—How should the degree of shade be regulated, and how is this illustrated? 1026.—What objection is made to the growing together of wheat and rye? 1027.—What would be preferable?

Mrs. B. It is supposed that the species which is best adapted to the soil will thrive so well as to choke the others; but it would be a more judicious mode of proceeding, to try by experiment, which kind of grass was best suited to the soil, and sow that alone.

On the confines of the cultivation of vineyards, that is to say, in those latitudes where the vine with difficulty ripens, the cultivator aims at producing a large quantity rather than a superior quality of wine. For this purpose the vines are frequently trained on trees, which multiplies the fruit at the expense of its flavor.

Caroline. It is singular that the same mode should be resorted to, in climates which are too cold, as well as in those which are too hot for the vine. In Italy they are trained on trees, to afford them shade; but on the cold confines, shade must be very prejudicial, more so, I should have thought, than would be compensated by the increase of production.

Mrs. B. On the limits of the vine countries, the great demand for common wine, in order to avoid the expense of its carriage from more distant parts, ensures a sale for wines of the lowest description.

Maize or Indian corn forms an *assolement* with peas and French beans: it affords a support to these climbing plants; and, being of the grass tribe, its exudations are favorable to leguminous plants.

Emily. It is inconceivable what an abundance of produce the earth yields under the influence of a southern sun. In Tuscany we have seen flourishing together, in the most perfect harmony of culture, the olive, the vine, corn, and a variety of leguminous plants.

Mrs. B. And yet the soil of Tuscany is not very favorable to vegetation. It is, indeed, well cultivated; the Tuscans, after the Belgians, being esteemed among the best of agriculturists; and they have, as you observe, the advantage of a most prolific sun. It is for this reason that they, in common with the cultivators in warm climates, aim at producing a numerous simultaneous *assolement;* whilst the Belgians, with the inhabitants of other temperate climes, must content themselves with a succession of

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1028.—What is said of mixing different kinds of grasses together? 1029.—Of what does the cultivation of the vineyard aim in high latitudes? 1030.—What takes place on the limits of vine countries? 1031.—With what does maize form an assolement? 1032.—What has Emily seen in Tuscany?

crops. The *assolements* of a Belgic farm, we have observed, extend from ten to fifteen years, the farm consisting generally of about forty acres; in Tuscany they are usually circumscribed to fourteen acres, with a soil inferior to that of Belgium; yet the more ardent sun of Italy produces a result nearly similar. In Tuscany the farmer is not obliged to rear his crops in slow succession; they are poured upon him, as it were, from the cornucopia of abundance: oranges, lemons, olives, melons, peaches, corn, and vegetables spring up together, to delight his eyes and to heap his board.

It is remarkable that these two countries, now so distinguished for agriculture, were once no less celebrated for their commerce.

Emily. This seems reversing the natural order of things; for, in general, it is the abundance of agricultural produce which leads to the establishment of manufactures and trade.

Mrs. B. That is certainly the most usual mode of progressive improvement. On the other hand, when a people enrich themselves by commerce, it is a very natural consequence that they should lay out some of their wealth in the improvement of land. Then it so happened, that, as Europe advanced in arts and civilization, commerce, which began first to flourish in Tuscany and Belgium, and was, indeed, almost exclusively confined to those countries, became more generally diffused. Political events also tended to diminish the trade of these countries; and, when it fell into decay, agriculture proved a fortunate resource for the wealth and industry of the people. They transferred to this employment not only their capital but that spirit of speculative enterprise, wisely regulated by those habits of calculation and of order, which distinguished them as merchants; and, when engaged in any hazardous experiments, the regularity of their accounts gave them exact results, and showed them whether they ought to be prosecuted or abandoned. This union of energetic vigor and methodical arrangement has achieved the wonderful enterprises of these excellent agriculturists.

1033.—What comparison is made between agriculture in Belgium and Tuscany? **1034.**—How is the farmer of the latter enabled to see his crops? **1035.**—What is mentioned as remarkable in these two countries? **1036.**—How does Mrs. B. account for this change?

CONVERSATION XV.

ON THE PROPAGATION OF PLANTS BY SUBDIVISION.

Mrs. B. It is now time to turn our attention from the preparation of the soil to the study of the plants which are to be raised in it.

Caroline. After having provided suitable accommodation for their reception, and an abundant store of food for their subsistence, they will no doubt increase and multiply with rapidity.

Mrs. B. That is not all. If we have taken so much pains to provide for the welfare of the vegetable creation, it is with the interested view of its affording us food and raiment; we shall therefore select for cultivation such plants as are best suited to that purpose.

There are two modes of propagating vegetables: the first consists in subdividing the parts of a plant, so that from one individual several may be formed; the second mode is that of raising new plants by the germination of the seed.

In order to be able in every case to distinguish these two processes, you must observe that the seed is always contained in an envelope, and that it is prepared by organs exclusively destined for that purpose. These organs compose the flower or blossom. Now the plant which results from the germination of the seed, is always of the same species as that in which the seed originated; but varying from it frequently in the quality of its fruit, and not inheriting any of the peculiarities which may have casually distinguished the individual parent-plant.

When, on the contrary, a new plant is raised by separating from the parent-stock a slip or a layer, you not only produce an individual of the same species, but, if I may so express it a continuation of the same plant, possessing every peculiarity by which it may casually be distinguished from others of its species.

Emily. When these peculiarities are of an advantageous nature, it must be desirable to raise the plant by division; otherwise, I suppose, it is more easily accomplished by sowing the seed.

1037.—What are the two modes of propagating vegetables? 1038.—What must be observed in order to distinguish these two processes? 1039.—What is said of the plant produced from seed? 1040.—And of one produced from a slip?

Mrs. B. But the process is much more tardy A seedling tree of ten years' growth will perhaps not be more advanced than one raised by a slip of five years old; then, when you are provided with a plant which bears remarkably fine fruit, you are sure that if propagated by division it will produce fruit of equally good quality. This mode affords, therefore, the most certain means of improving the species.

Caroline. Reproduction by seed is the mode adopted by Nature; that by division the invention of art.

Mrs. B. The latter is also sometimes employed by Nature, as you will see.

Reproduction by division tends to diminish the quantity of seed. The vine, which in a state of nature, bears five seeds in each grape, when propagated by this mode, has only two; and some vines loose them entirely, so as to leave no possibility of re-producing the plant but by division.

Emily. The fruit no doubt profits by this deficiency of seed, as the sustenance which would go to ripen the seed, will be expended in enriching the juices of the grape. I have observed that apples and oranges, which have the fewest pips, are the highest flavored.

Mrs. B. The remark is applicable to fruits in general. The sugar-cane, propagated by division, wholly loses its seed; and so do also the succulent plants of the Cape of Good Hope, after having been for a number of years transplanted into Europe.

Caroline. But I cannot comprehend how a slip can strike root. That root, branch, and every part of a plant should be developed by the germination of a seed, in which it existed in a latent state, is easy to conceive; but that a root should grow from the extremity of a young shoot seems to favor the idea of casual reproduction, which is not to be met with in Nature.

Mrs. B. There is reason to suppose that germs, in some respect analogous to those which are contained in the seed, exist in almost every part of a plant, but are not developed unless placed under favorable circumstances;

1041.—What comparison is made between a seedling tree and one raised by a slip in relation to the time needed for their growth? 1042.—How is the quantity of seed effected from re-production from slips? 1043.—How does Emily say the fruit is effected? 1044.—How are sugar-cane and the succulent plants of the Cape of Good Hope affected? 1045.—What is it reasonable to suppose exists relating to production of roots to the new slip?

that these germs are of two distinct species, the one producing stems, the other roots. The former originate chiefly in the axilla of the leaf, or part which unites the leaf to the stem; and which, from the analogy it bears to the union of the arm to the body in the human frame, is called the axilla: the latter shoot out roots on each side.

It has been affirmed that roots may, by exposure to the air, be converted into branches; and branches, by being buried in the earth, transformed into roots; and this, as I believe I before mentioned to you, has been attempted to be proved by overturning a willow, burying the head in the ground, and leaving the roots upwards exposed to the air. But what was the result? Not that the branches became roots, and the roots branches; for the former being unfurnished with the organs of absorption, and the latter with those of evaporation, it was impossible for them to exchange their respective functions; but the branches being deprived under ground both of light and air, and of all the circumstances favorable to the developement of the germs of other branches, these branches do not shoot. The same circumstances being, on the other hand, particularly adapted to the developement of the germs of roots, these strike out into the soil.

In the mean time the roots, which have been compelled to change places with the branches, being exposed to the light and air, and so situated as to favor the developement of the germs of branches, and in direct opposition to that of the germs of roots, shoot out young branches from their naked roots, and in the course of time cover them with foliage.

Emily. I recollect having seen the leaf of a plant, which, when simply laid upon moist ground, struck out roots from its edges into the soil.

Mrs. B. This is the Bryophyllam: The flower is the only part of a plant which is incapable of developing either a root or a stem, except through the medium of the seed, the production of which is its sole and exclusive function.

There are three modes of multiplying plants by division:—

1046.—How do these two species of germs originate? **1047.**—What unnatural change, has it been affirmed may be caused with certain trees? **1048.**—When the experiment was made with the willow what was the result upon the branches? **1049.**—And upon the roots? **1050.**—What is said of the Bryophyllam?

The first by layers;
The second by scions, or slips;
The third by grafts.

When you intend to multiply by subdivision, you place that portion of the plant which you intend to separate from the remainder under such circumstances as are requisite to enable it to develope the organs in which it is deficient, and which are necessary to its independent existence. If it be a branch, the organ wanting is a root; if it be a root, the organ necessary to be developed is a stem. How is this to be accomplished.

Emily. You must, I suppose, bury the extremity of the branch in moist ground, to favor the developement of roots; and, in the other case, train the roots above ground to encourage that of branches.

Mrs. B. Exactly. It is the cambium, you must recollect, which, in its retrograde course through the liber, and partly through the alburnum, nourishes these germs; if, therefore, you propose to develope them in any particular part of the plant, you must accumulate the cambium in that spot. This may be done in several different ways. In the first place, you may make an annular incision in the bark or rind, and, by thus impeding the descent of the cambium, accumulate it in the upper section, where it will produce a swelling or protuberance of the bark. The germs situated in the neighborhood of this rich magazine of food, if in other respects favorably circumstanced, are developed; that is to say, if the annular incision be exposed to light and air, the germs of branches will shoot; if below ground, those of roots will strike into the soil. Indeed any casual interference with the descent of the cambium is almost immediately followed by the sprouting of a bud. In order to make a layer, you bend down a pliant branch without separating it from the plant, and fasten it in the ground; sometimes a slight incision is made at the spot in which it is confined.—Now, what follows? The cambium, descending through the branch, finds some difficulty in returning to the stem: this obstacle is suffi-

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1051.—What are the different ways of multiplying plants by division? **1052.**—How is it to be done? **1053.**—What does Mrs. B. say must be recollected? **1054.**—How are germs made to develope themselves? **1055.**—If the annual incision be above ground what will be the result; and if below ground what will it be? **1056.**—In order to make a layer what is done?

cient to occasion a small accumulation, and the shooting out of several germs of roots.

There are some creeping plants which propagate themselves in this manner without the aid of man. Their lower branches, trailing upon the ground, are often partially covered with earth washed over them by the rain: if, in this operation, they are slightly wounded by friction, or the contact of any hard substance, such as gravel or pebbles, the free passage of the cambium is interrupted, roots strike out, and the branch which connected them with the parent-stock, being in a great measure deprived of its nourishment by the young roots, rots and perishes; the separation is thus made, and the requisite organs being developed, the layer becomes a new individual plant.

Caroline. I have seen carnations and ranunculuses thus propagated; and I am delighted to hear the explanation of an operation I have often witnessed without understanding it.

Mrs. B. Laurels and most evergreens are also propagated by layers; and it is the regular mode used in vineyards. A branch of vine is laid under ground, and the extremity of it raised up above the soil in that spot where you wish to produce a new plant. If the branch be long and pliable, several plants may be made to spring from it. This is called a serpentine layer, because the branch takes a serpentine direction, being made alternately to sink below and rise above ground, as often as it is intended that new roots and stems should shoot from it.

Layers are sometimes made in arches by burying the extremity of the branch only; the separation is afterwards made when the branch has struck root: this mode is particularly suited to the raspberry and every species of bramble.

Caroline. I have heard that there is a tree in Senegal called the Mangrove, or Rhizophora, whose branches, descending to the ground, bury their extremities in the soil, and strike root, thus forming beautiful natural arcades around the parent stem.

1057.—What is the result? 1058.—Without the aid of man what plants propagate themselves in this way? 1059.—How is it done? 1060.—How are laurels, evergreens, and vines propagated? 1061.—What is called the serpentine layer? 1062.—In what other way are layers sometimes made?

Mrs. B. Several fig-trees in the East Indies grow and propagate in the same manner. The ancients sometimes twisted the branch at the spot where they wished a root to strike: to this process we have substituted the more gentle mode of strangulation by ligatures, which injures the branch less, and yet arrests the cambium sufficiently to produce an accumulation.

Another mode of making layers consists in slitting the branch from the bottom upwards, and drawing the portion slit on one side, so as to form the figure of a Y reversed, the branches being of unequal length. The portion of the cambium which descends into the slit, finding no vent, accumulates and strikes root.

Emily. I have seen the gardener propagate the Magnolia, and other rare and delicate plants, by gently bending some of their most pliant branches to the ground, and covering every part of them with earth excepting their extremities; by this means a considerable number of layers may be obtained at a time.

Mrs. B. Layers are also sometimes made completely above ground, though, it is true, this cannot be done without the aid of the soil; for it is necessary that the branch should be surrounded with moist earth, which may be contained either in a flower-pot or a small basket, having an opening sufficiently large to admit of the branch passing through it.

Caroline. The germs then strike root in this soil. I have seen the Oleander propagated this way.

Mrs. B. M. Humboldt, the celebrated naturalist, when travelling in America, provided himself with strips of coarse pitched cloth, which he substituted in the place of a basket, to confine the earth round branches from which he wished to make layers. He adjusted them round the branches of trees, in forests through which he intended to return some months afterwards when the roots would have shot out; and by this means he brought over to Europe a number of very curious and valuable new plants, which have not only enriched our botanical gardens, but have been generally disseminated both for use and ornament.

1063.—What is said of the propagation of fig-trees? 1064.—What is the mode of making layers, by slitting the branch? 1065.—How is the magnolia propagated? 1066.—How can layers be made completely above ground? 1067.—What is related of Humboldt?

The most favorable season for propagating by layers, in these temperate latitudes, is the latter end of February or the beginning of March. This season is called by gardeners the first spring: it precedes the ascent of the sap, and enables the layers to collect the first drops of cambium which are elaborated. In England and other northern climates, where vegetation is less forward, the end of March, which is called the second spring, is sufficiently early for this purpose. The month of April, in which the budding of the leaf takes place, is denominated the third spring.

The safest way to ensure the success of layers is to leave them a year without separating them from the parent stock, in order to give them the chance of striking root during the ascent of the autumnal sap, if they have failed to do so in the spring.

Both succulent and aqueous plants are very difficult to propagate by layers; because the cambium, instead of forming a protuberance to nourish the germs, runs out and is lost. The operation is more likely to succeed on plants of this description by strangulation than by incision.

The propagation of plants by slips is very analogous to that of layers; indeed the only difference is, that the branch you destine to become a new plant is separated from the parent stem previous to the developement of those organs which are necessary to insure it an independent existence.

Caroline. I am much better acquainted with this species of propagation, I have raised so many geraniums by slips. Nothing is more easy: you merely cut off a young branch, and plant it in a pot of earth. But I am completely ignorant how it lives: whether it absorbs water before it strikes root, or whether it nourishes the embryo roots by its own substance.

Mrs. B. I believe no one can boast of having a perfect knowledge of the process; but I am inclined to think, that the cambium which descends in the slip, and which was destined to nourish the lower part of the

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1068.—In temperate latitudes what is the most favorable season for propagation by layers? **1069.**—What one in England? **1070.**—What is called the third spring? **1071.**—What is the most safe way to secure the success of layers? **1072.**—What is said of propagating succulent and aqueous plants by layers? **1073.**—What is the difference between propagating plants by slips and by layers?

branch whence it was cut, finding a sudden termination to its course, exudes. The first drops fall into the soil; but, from its viscous nature, those which follow soon coagulate and heal the wound. The protuberance then forms, and roots strike out.

Caroline. This process must, however, be attended with much greater uncertainty than by layers. The slip, being separated from its parent, before it is able to provide for its own wants, is like a child brought up by hand; whilst the layer is weaned only after it has acquired the power and the means, of finding its own nourishment.

Mrs. B. It is for this reason that the propagation of rare plants is preferable by layers. There are some trees which have such a remarkable facility for sprouting, that whatever part of them you plant in the ground will strike root, be it a branch, the remnant of a stem, or even a simple stake. The willow, the ash, and most trees of white wood, sprout with this facility. The weeping willow is so easily propagated by slips that it is never raised by seed; and all the willows now existing in Europe, and, in all probability that ever will exist there, are subdivisions of one tree brought originally from Asia.

Emily. Greenhouse plants are usually propagated by slips from shoots of the preceding spring; and sometimes the slip is cut a little below the spring-shoot, so as to include a piece of the shoot of the preceding year.

Mrs. B. This is for the purpose of preventing the extravasation of the cambium, the wood of two years' growth being of a more solid texture.

Branches of three or four years' growth are sometimes planted: they should be placed deep in the soil, to favor the developement of a number of germs. Slips of forked branches are planted with advantage for hedges, as their shoots interlace each other, and form an impenetrable fence.

In raising succulent plants by means of slips, it is necessary either to dry up or cover with mastic the cut end, for

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1074.—When by slips, how is it supposed, they are made to live? **1075.**—To what does Caroline compare the propagation of plants by slips? **1076.**—What is said of the facility with which some trees sprout? **1077.**—What are they? **1078.**—How are green-house plants propagated? **1079.**—Why are they cut below the spring shoot? **1080.**—What is said of branches of three or four years growth, and of slips of forked branches?

the purpose of retaining the cambium: in the isles of France and of Bourbon it is usual to carbonise the ends of slips, in order to prevent its escape.

When you propagate by slips of roots, you must plant them near the surface, in order to facilitate the sprouting of stems. Jessamine, strawberries, and, probably, mushrooms, are propagated in this manner.

Emily. I thought that mushrooms were propagated by a species of seed called the spawn.

Mrs. B. The white filaments, vulgarly called the spawn of mushrooms, are in fact the fibres of its roots; these are cut in pieces and sown; or rather, I should say, planted in a hotbed.

Caroline. In planting potatoes, it is not requisite to leave a spot, called an eye, in each piece? It is from these, I understand, that both stems and branches sprout.

Mrs. B. These eyes are the germs of embryo stems and roots. The potatoe is nothing more than a tubercle formed by an accumulation of cambium in the subterraneous branches of the plant, and destined to nourish the buds which are to be developed the following season. This storehouse of food offers such facility to germination, that when potatoes are heaped in a cellar, of a moderate degree of temperature and moisture, the germs absorb nourishment from the farina of the potatoe and sprout, either roots or stems, according as their situation favors the developement of the one or the other of these germs.

Caroline. In what an enviable situation these germs are placed! enclosed in a magazine of food—breathing as it were, an atmosphere of nourishment, and inhaling it at every pore.

Emily. Not more so than the germ of a bird, which subsists on the yolk and albumen of the egg until its frame is fully developed.

Caroline. True; it is singular what analogy there is between the different productions of Nature, and what a fund of knowledge may be derived from them!

Mrs. B. A fund equally inexhaustible and admirable!

1081.—How should the slips of succulent plants be prepared—how are they in the isles of France and Bourbon? 1082.—How are slips of roots planted—what ones are named? 1083.—What are the spawns of mushrooms? 1084.—What is the potatoe said to be? 1085.—What is said of the facility with which they germinate? 1086.—What is the germ of a bird? 1087.—What are the works of creation to be considered?

We may consider the works of the creation as a natural revelation, in which we read the history of the stupendous operations of the Deity; and which, the more we study, the more we raise our minds towards just ideas of their Divine Author, and elevate our hearts by the contemplation of the blessings he has so bountifully lavished upon us. Not only are we provided with every thing necessary to our existence, but care has been taken that even this, our transitory state, should be rendered agreeable: our food, instead of being insipid or loathsome, is delightful to the palate; the landscape, spread before our eyes, instead of being dark or monotonous, is illumined by a splendid sun, and variegated by a thousand hues; delicious odors arise from flowers of enchanting form aud color; in a word, Nature contains innumerable sources of enjoyment, which develope and strengthen a spirit of grateful devotion towards their beneficent Author.

CONVERSATION XVI.

ON GRAFTING.

Mrs. B. We may now proceed to the art of grafting, an operation from which we derive our finest fruits. It consists in placing a portion of one plant in juxta-position with another, in such a manner that they shall unite and grow together. The branch which is cut from one tree, to be transferred to another, is called the *graft*, or *scion*, and the tree to which it is transferred the *stock*.

Caroline. This, then, is not a mode of multiplying plants, but of changing their nature; for if a branch of one plant be added to another plant, the number is not increased.

Mrs. B. Certainly not. The advantage of grafting consists in improving the quality, not augmenting the number, of plants. The ancients entertained very exaggerated ideas of this art: they conceived that every species of plant might be grafted on each other; but it is now well ascertained that this operation can be performed only

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1088.—How are the particular parts of nature suited to our happiness? 1089.—What is grafting? 1090.—What is the graft and the stock? 1091.—What is the advantage of grafting? 1092.—What erroneous opinions were entertained by the ancients on the subject?

on plants of the same family. To ensure the success of a graft, it is necessary that the vessels of the liber of the two plants should meet and correspond, in order that the cambium should descend from the graft into the stock; for it is by the union of the vessels of the bark of both plants that they are soldered, as it were, together.

Caroline. Then endogenous plants, since they have no bark, cannot be grafted?

Mrs. B. No; at least that operation has not hitherto been performed upon them with success.

Some anatomical analogy is also requisite in the form, the structure, and dimensions of the vessels, which is only to be met with, in plants of the same family. A certain degree of physiological similarity is besides necessary; such for instance, as that the sap in both plants should rise at the same period. There must also be a correspondence in the size and strength of the plants; for instance, the lilac may be grafted on the ash; but, as the latter has a much greater power of suction, the graft is, gorged by the quantity of sap which is thrown up into it, and dies of plethora. If, on the contrary, the ash be grafted on the lilac, the graft perishes for want of nourishment.

A plant which loses its leaves in winter cannot be grafted (at least not without great difficulty) on an evergreen: the latter, absorbing a small quantity of sap during the winter, would send it up into the graft, which would sprout, in a season in which the young shoots would be destroyed by the frost.

Caroline. And if, on the other hand, you were to graft the evergreen on a plant which loses its leaves, the graft would perish of famine.

Mrs. B. Very true; the last analogy required in grafting is, that the two plants should thrive in the same temperature.

When a tree is grafted, the graft will always bear its own fruit, and the tree its own also.

Emily. I am surprised at that. Suppose that a branch of cherry were to be grafted on a plumb-tree; the sap ab-

1093.—To ensure the success of a graft what is necessary? 1094.—What anatomical analogy and what physiological similarity should be regarded? 1095.—Of grafting the ash and the lilac, what is said? 1096.—Of a plant which loses its leaves in winter and the evergreen what is said? 1097.—What is the best analogy required in grafting?

sorbed by the latter rises through it into the graft, and, being elaborated in the leaves of the branch of the cherry-tree, I should have supposed that it would have changed the nature of the fruit of the plumb-tree when in its descent it returns into it.

Mrs. B. No; for though the rising sap is the same for both stock and graft, it is different in its return. The sap of the stock and that of the graft are each elaborated by their respective leaves, and, when converted into cambium, each supplies nourishment to its own variety.

Mr. Knight has made many ingenious experiments, which tend to show that each variety of fruit requires its own peculiar leaves to bring it to perfection. He grafted several varieties of apples and pears on trees of the same species, and adjusted the grafts close above the flower-buds on the stock: these buds blossomed and bore fruit so long as leaves were suffered to remain on the tree; but in some experiments he stripped them off, so that the sap could be elaborated only in those of the graft, and in those instances the fruit always withered and fell off.

The principal advantage of grafting consists in its affording an easy means of propagating individual plants, which have, either by cultivation or some casual circumstance, attained a high degree of perfection.

Emily. This is similar to the advantages obtained by the propagation of plants by layers or slips.

Caroline. I have heard that it is necessary to graft fruit-trees raised from seed, in order to make them bear fruit; yet, if it were so, no fruit would grow wild; and in a state of nature plants could not produce seed to continue their species.

Mrs. B. It is quite erroneous to suppose that seedling fruit-trees will not bear fruit in due time; but this period will be considerably accelerated by grafting. A young tree is not sufficiently strong during the first years of its existence to bear fruit: an apple-tree, for instance, produces none until it has attained the age of ten or twelve years; but, if grafted from a tree that has already

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1098.—What does Mrs. B. say to Emily who proposed grafting the plumb and cherry tree? 1099.—What do the experiments of Mr. Knight tend to show? 1100.—What were they? 1101.—What is the principal advantage of grafting? 1102.—What erroneousopinion of seedling fruit trees is mentioned? 1103.—How much is the gain of time in having fruit from grafting?

borne fruit, it will blossom and produce fruit sometimes as early as the second or third year.

Caroline. Yet grafting cannot increase the age or strength of the seedling-tree?

Mrs. B. No; but the buds on the graft have attained a state of vigor and perfection which enables them to produce seed; and the seedling-tree may be considered merely as the channel by means of which nourishment is conveyed to them, until age has given it sufficient vigor to produce fruit-buds of its own. Grafting increases the size of fruits at the expense of the seeds: the rose acacia, when not grafted, bears seeds; when grafted, it bears none, but its blossom is much finer.

Grafting sometimes produces a change of flavor, and generally retards vegetation: it is often employed as a means to retard that of trees, which bud so early in the spring as to be in danger of suffering from the frost. The walnut, for instance, buds a full fortnight later when grafted on walnut.

In regard to the mechanical part of the process, care must be taken to fasten the graft to the tree with soft ligatures, and in such a manner that the vessels of the respective barks may come into contact; then, in order to prevent the extravasation of cambium, the wound must be well covered over with a ball, which is generally made of cow-dung and stiff clay. The composition which M. De Candolle recommends for this purpose consists of one pound of cow-dung, half a pound of pitch, and half a pound of yellow wax.

The season for grafting is either in the spring during the ascent of the sap, or in the autumn for the sap of the following spring.

Caroline. But does not the sap rise constantly throughout the summer?

Mrs. B. For the purposes of general vegetation it does; but you must recollect that all germs and buds, are fed by sap, elaborated by vessels appropriated exclusively for that purpose; advantage must therefore be

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1104.—Why is this gain? **1105.**—How is the size of the fruit, and how are the seeds affected by grafting? **1106.**—What is said of the effect it has on the period of vegetation? **1107.**—In regard to the mechanical part of grafting what is said? **1108.**—At what season should it be done? **1109.**—Why may it not be done in summer?

taken of the period when this sap is in full flow, to effect the junction of the two plants.

M. Chondi has distinguished himself by the numerous experiments he has made in the art of grafting: he divides the plants susceptible of undergoing this operation into three classes.

1. The *Unitiges*, or plants having one central and vertical stem, such as firs, larches, and most evergreens. In these it is the stem which must be grafted, and not the lateral branches

2. The *Omnitiges*, every branch of which is equally a stem, and therefore each is capable of being grafted.

3. The *Multitiges*, plants in which some branches are stems and susceptible of being grafted, and others are not so.

M. De Candolle once saw every branch of a large pear-tree grafted: this was done in order to preserve a great number of grafts, which had just been received from a foreign country. The following year they were each transferred to separate trees, and succeeded extremely well.

Emily. And how are grafts, when brought from distant countries, preserved alive?

Mrs. B. Frequently by dipping them into honey, which, by preventing evaporation, preserves the internal moisture. Another mode is to bury the cut end of the graft in a moist root, such as a carrot or a turnip.

It would be very difficult for me to explain all the various manners of grafting, there being above a hundred, which may be divided into three classes.

1. Grafting by approach. You bring together two branches of two neighboring trees, and, cutting off the extremities of each, you graft them together. If three trees be united together in this manner, the stem of the central one may be cut down, and the head will be kept alive and nourished by its two neighbors.

Caroline. This must be a safe mode of grafting rare and delicate plants, as it is attended with no risk; for sup-

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1110.—Who has distinguished himself for experiments in this art? 1111.—What are the three kinds of plants susceptible of this operation? 1112.—What is stated of a pear tree by Candolle? 1113.—How are grafts preserved when brought from distant countries? 1114.—How many different modes of grafting are there? 1115.—What is the first and how is it described?

pose the junction does not take place, each branch remains uninjured and grows separately, so that nothing is lost.

Mrs. B. It is a good mode, also, for common plants, being so easy and rapid in its results.

Caroline. And might not in a similar manner several stems be united to a single head?

Mrs. B. Yes; if a circle of stems of young poplars be bent and united in a centre, they will form but one head, which, nourished by the surrounding stems, will grow to an enormous size.

Some trees graft themselves spontaneously. If two branches of *hornbean* happen to grow so close together as to rub against each other when moved by the wind, the outer bark will be worn away by the friction, and the vessels of the two libers will come in contact, which is sufficient to produce a graft. The mere act of two branches growing contiguous, when confined for space, will wound the bark; and, indeed, by whatever chance the vessels of two branches are brought together, in such a manner that the sap can flow from the one into the other, a graft takes place.

Emily. You sometimes see a young tree growing from the trunk of an old one of a different kind: is this the result of a natural graft?

Mrs. B. No; it is that of a seed which has sown itself, or of a slip which has planted itself in the hollow of a decayed tree, the rotten wood producing a soil which consists wholly of the richest nourishment. I have seen a fine young cherry-tree grow out of the hollow trunk of an oak, and a vine spring from the old stump of a willow.

Emily. You sometimes see two leaves and two flowers cohering together: is not this owing to a natural graft?

Mrs. B. Yes; this species of grafting extends also to fruits: the double cherry is thus grafted.

Caroline. Pray, are roots susceptible of being thus grafted?

1116.—For what plants is this mode particularly adapted? **1117.**—How is it said that several stems might be united to a single head? **1118.**—What instances of spontaneous grafting is named? **1119.**—When a young tree is seen growing from the trunk of an old one of a different kind, how is it produced? **1120.**—What instances of this have been seen? **1121.**—What other cases of this mode of grafting are mentioned?

Mrs. B. It has been so affirmed, but it may probably be an error, arising from confounding subterraneous branches with roots.

The second mode of grafting, and which is in most common use, is by scions: a young branch is cut off from one plant, and grafted on another. In whatever manner the section be made in the graft, one of a corresponding form must be made into the subject, in order that they may fit into each other, and the vessels of the liber come into contact; the union then takes place in the course of a few days.

Emily. The mode of grafting by approach bears a considerable analogy to the propagation by layers; and that by scions, to the propagation by slips or cuttings.

Mrs. B. True; and the third class, which is grafting *bourgeons* or buds, may in some respects be compared to propagation by seed: it consists in transplanting a bud from one plant to another. For this purpose the bud must be separated from the parent-plant, in such a manner as to be surrounded by a small disk or shield of bark; for since the union is effected by the vessels of the bark, it is through its intervention alone that the bud can be grafted. A small piece of the alburnum is sometimes cut off in addition to the bark, but I believe this to be an unnecessary precaution. The bud may be adjusted on any part of the bark of the tree, but it is more sure to succeed, if it be grafted on a spot where another bud had previously existed, in order that the vessels which conducted nourishment into the original bud, may pour it into that which is substituted in its place. In this manner Mr. Tschudy has succeeded in grafting herbaceous plants,—the melon, for instance, on the gourd; and potatoes on tomatas; but one herb cannot be grafted upon another. This species of grafting is rather novel, it being formerly supposed that herbaceous plants were not susceptible of being grafted.

The embryos of buds, before they begin to be developed you may recollect, are called eyes; and the graft may be made either when the eye is said to be sleeping or wak-

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1122.—What is the second mode of grafting and how is it described? **1123.**—What is the third mode? **1124.**—How is it done? **1125.**—What experiments were made with it by Mr. Tschudy?

ing: that is to say, either in autumn when the eye is closed for its long winter-night of repose; or in spring, when it is open for its summer-day of activity.

Another mode of grafting buds is by transplanting a broad ring or flute of bark, containing several eyes, and substituting it in the place of a similar ring cut away from the stock: this is less sure of success, on account of the number of buds to be nourished.

These several modes of propagation by layers, by slips, and by grafts, are all calculated to improve the fruit; the grand source of the multiplication of plants is the seed, which we shall enter upon at our next interview.

CONVERSATION XVII.

ON THE MULTIPLICATION OF PLANTS BY SEED.— THE FLOWER.

Mrs. B. We have now reached that part of our subject with which you thought it would have been proper to have commenced—the history of the seed. It will be necessary to introduce it by a description of the organs whose office it is to prepare this important part of the plant

Caroline. That is to say, the flower, which forms the principal part of the study of botanists in general, and which we have hitherto totally neglected.

Mrs. B. If I have allowed the most beautiful part of the vegetable creation to remain so long unnoticed, it was in order that, when I described it, your interest might be excited, not merely by the brilliancy of its colors, the elegance of its form, or the sweetness of its perfume, but that, having acquired some previous knowledge of the economy of vegetation, and become acquainted with the essential part it performs among the works of Nature, you would take a deeper and more rational interest both in the blossom and the seed, and that your admiration would be excited by learning, that the most beautiful part of the vegetable kingdom, prepares and ushers into life, that which is most useful. No child has so richly ornamented a cradle as the seed when reposing within the recesses of the flower.

1126.—At what period may it be done? 1127.—What is another mode of grafting buds? 1128.—Why has Mrs. B. delayed so long the description of the flower?

The flower consists of several parts.

The *calyx*, or flower-cup, forms the external integument which shelters and protects the bud before it expands: it consists of several parts, called sepales, resembling small leaves, both in form and color; and probably performs similar functions, being furnished with stomas. These sepals are, in general, more or less soldered together, sometimes so completely as to form a cup apparently of one piece: hence the calyx has acquired the name of flower-cup.

Caroline. I see that you persevere in deriving every organ of a plant from the budding of leaves.

Mrs. B. When you are a little more acquainted with plants, I think that you will concur with me in this opinion.

Above the *calyx* rises the *corolla*, which is the colored part of the flower. It is composed of several petals, either distinct and separate, or cohering so as to form a corolla of one single piece: in the latter case the flower is called monopetalous, though the petals are never originally simple, as this name would seem to imply, but, like the calyx, derive their origin from a circle or *whorl* of leaves. When the petals first burst from the calyx, and expand in all their beauty, they still serve to protect the central parts of the flower: they are at first curved inwards, forming a concavity around the delicate organs which occupy the centre, which not only shelters them from external injury, but reflects the sun's rays upon them like a concave mirror, thus rearing them as it were in a hothouse. When they are full grown, the artificial heat being no longer necessary, and the admission of light and air not only safe but advantageous, the petals expand, leaving the internal organs exposed to the free agency of these elements.

At the base of the petals is generally situated the *nectary*, so called from its secreting a sweet fluid, which has been dignified by the name of *nectar*. This is the store whence the bee derives honey: it affords also abundant provision for the less provident insect tribe, who, rioting in these sweets during a summer, scarcely outlive the fall of the blossom. These thoughtless beings, however un-

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1129.—How is the calyx described? **1130.**—Why is it called the flower cup? **1131.**—What is the corolla? **1132.**—Of what is it composed? **1133.**—What are its uses? **1134.**—What is said of the nectary?

wittingly, act a useful part in the economy of Nature, which I shall presently explain to you. The nectar exists in almost all flowers, but is not always contained in a distinct organ.

Caroline. I have often sucked it from the tubular orifice of the petals of the honeysuckle.

Mrs. B. That flower produces a great quantity of honey, and part of it lodges in the elongated tube whence you suck it.

The most important parts of the flower are those delicate organs which occupy the centre as the place of greatest security. It is here that the seed, which is to propagate the plant, is lodged. It is enveloped in a small leaf, which, instead of expanding its beauties to the sun and air, like its neighboring petals, folds itself more closely around the little treasure it is to protect: the edges of the two opposite halves of the leaf being thus brought in contact, they unite and grow together, and the leaf assumes the form of a pod, or vessel, the shape of which varies according to the manner in which the leaf was folded when it first budded.

Caroline. And will you not admit that plants have sensibility, Mrs. B., when you see them showing such signs of maternal care for their offspring?

Mrs. B. No, my dear. Were I sufficiently versed in the physiology of plants, I should no doubt be able to show you, that this tender care of the protecting leaf is the natural result of physical law.

Caroline. Then I am almost tempted to rejoice that you are not learned enough to do so. I cannot help being vexed when I hear facts, so interesting to the feelings, explained away by the dry results of mechanical or chemical laws.

Mrs. B. You are falling into an error very common among half-learned and superficial observers.

When you feel inclined to murmur at the dry results of physical laws, let not your imagination rest there, but raise your mind from these impassive agents, to their Omnipotent Author: you will then consider them as the un-

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1135.—What is said of the honey suckle? **1136.**—What are the most important parts of flowers? **1137**—How is the seed preserved? **1138.**—If sufficiently versed in the physiology of plants what does Mrs B. say she should be able to do? **1139.**—What is the ovary?

erring instruments which his paternal care has provided, to promote and secure the welfare of his creatures.

Caroline. I now understand and perfectly acquiesce in your sentiments. It is very true that the mind, amazed at the wisdom that is displayed in the laws of Nature, is apt to consider them as a sort of mechanical cause, rather than as mere agents of an all-wise and sentient Power.

Mrs. B. To return, then, to the flower and the envelope of the seed, in which, I trust, you will continue to take some interest, although we have deprived it of sensibility; —unless in a poetic sense. When this leaf is closed over the seed, and its edges soldered together, it is called an *ovary*, or seed-vessel. From its summit rises a little thread-like stalk, called a *style*, which, at its extremity, supports a small spongy substance, denominated *stigma*. These three parts form a whole, which bears the name of *carpel*.

Emily. Is carpel, then, synonymous with pistil? For I know that an ovary, with its style and stigma, constitutes a pistil?

Mrs. B. Pistils are composed, in general, of several carpels, which, in most flowers, are so neatly fitted to each other, and so closely adhere together, that they are considered as a single organ, containing different cavities for seed; but the most accurate anatomical researches prove that these several cavities have each its style and stigma, and form distinct carpels: thus, the blossom of the apple and the pear have several carpels soldered together.

Caroline. Oh, yes; for when they become fruits they contain several seeds.

Mrs. B. That would afford no proof of the pistil consisting of more than one carpel, which often contains many seeds; but in the apple and pear the seeds or pips are lodged in separate carpels. It is true, however, that a single carpel forms the pistil of some flowers; such, for instance, is the blossom of the cherry, which, you know, has but one seed, the kernel contained within the stone.

In some flowers, the styles and stigmas remain separate, and the ovaries are soldered together: the flower is then

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1140.—What is the style, the stigma, and the carpel of a flower? 1141.—How are pistils formed and what is said of them? 1142.—In what flowers does a single carpel form the pistil?

said to have two styles with one ovary, containing several cells or cavities for seeds; in others, it is the styles which adhere together while the ovaries are detached, and in some few the adhesion takes place only between the stigmas.

Immediately surrounding the pistil are situated the *stamens;* each of which consists of a slender filament supporting a little bag or case called *anther*, filled with pollen, a species of dust or powder. The anthers when ripe burst, and, being more elevated than the stigma, shed their pollen, upon it, and the seeds are thus perfected.

Emily. Yet I have heard that there are some plants whose flowers have no stamens, and others which have no pistils: in this case, how can the pollen of the stamens fall upon the stigma of the pistils? Nature has, no doubt, provided some resource to overcome the difficulty.

Mrs. B. Or, rather, it is a provision she has specially made in favor of another part of the creation. The pollen is sometimes conveyed by winged insects, which, in penetrating, by means of their long and pliant probosces, within the recesses of the corolla, in order to obtain the nectar, cover their downy wings with the pollen.

This unheeded burden they convey to the next flower on which they alight; and, in working their way to the nectary, it is rubbed off and falls on the stigma: this compensation they make for the honey of which they rob the flower; and they thus unconsciously labor for those plants, which afford them food. Every insect, however ephemeral, every weed, however insignificant, has its part assigned, in the great system of the universe.

In Persia, very few of the palm and date trees under cultivation have stamens, those having pistils being preferred, as alone yielding fruit. In the season of flowering, the peasants gather branches of the wild palm-trees whose blossoms contain stamens, and spread them over those which are cultivated, in order that the pollen may come in contact with the pistils and fructify the seeds.

1143.—What is said of the ovaries being detached or confined together in different flowers? 1144.—What is said of the stamens and anthers? 1145.—What objection does Emily make to what Mrs. B. says of stamens and anthers? 1146.—How does Mrs. B. reply to her? 1147.—What compensation do winged insects sometimes make for the nectary they obtain? 1148.—What is said of palm and date trees in Persia?

There are two remarkable palm-trees in Italy, which have been celebrated by the Neapolitan poet, Pontanus: the one, situated at Otranto, has no stamens; the other at Brindisi, which is about 40 miles distant, has no pistils, consequently neither of these trees bore seed; but when, after the growth of many years, they rose superior, not only to all the trees of the neighboring forests, but overtopped all the buildings which intervened, the pollen of the palm-tree at Brindisium was wafted by the wind to the pistils of that at Otranto, and, to the astonishment of every one, the latter bore fruit.

Caroline. How extremely curious!

Mrs. B. Having now completed our examination of the flower, it will be necessary to bestow some attention on the stalk which supports it. This is called a *peduncle*, or *pedunculus*. It generally expands a little at the summit, and forms a common base by which the several parts of the flower are connected together. This little expansion is called *torus*, which signifies a bed.

Emily. It is the bed on which the flower reposes; but it belongs to the stem, and, I believe, forms no part of the flower?

Mrs. B. You are quite right: the flower consists of the calyx, the corolla, the nectary, the pistil, and the stamens. If you pluck off these several parts, the tours will remain on the peduncle; but we shall see hereafter, that, though it forms no part of the flower, it sometimes enters into the composition of the fruit.

The peduncle is not always crowned by a flower: it often branches out into a number of smaller flower-stalks called *pedicels*, each of which supports a flower.

When pedicles diverge regularly from the summit of the peduncle, as rays from a centre, it is called an *umbel*, from the resemblance which the pedicels bear to the branches of an umbrella. A second umbel frequently shoots from each pedicle of the first; the umbel is then said to be compound.

Emily. I observe that the peduncle expands, so as to form a base for the pedicels which grow from it, and this

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1149.—And of two remarkable palm trees in Italy? 1150.—What is the pedunculus? 1151.—And what is called the torus? 1152.—Of what does the entire flower consist? 1153.—What are the pedicels? 1154.—What is called the umbel?

expansion is surrounded by a little circlet of leaves—probably bracteas?

Mrs. B. Yes they are, and are usually called the *involucrum* of the umbel. The base whence the pedicles radiate bears the name of *receptacle;* and it not only serves to support them, but, the sap being accumulated in this expansion, it becomes a reservoir of nourishment, and supplies them with food which they each convey to their respective flowers.

Emily. Does not the Laurustinus blossom in this manner? I have often observed that its peduncle spreads out into a number of different ramifications.

Mrs. B. They do not spring from a common centre, and, consequently, can have no common receptacle; but are irregular, like the branches of a tree, and the bunch of flowers they support may be compared to its head. It is hence called a *cyme* or *cyma.*

The peduncle often throws out small pedicels at regular distances, as you may have observed in a bunch of currants: this sort of cluster is called *raceme* or *racemus,* and its flowers open in succession from the bottom to the top.

In some plants the flowers are placed around the peduncle on such very short pedicels that they assume the form of a *spike* or *spica.* When thus disposed they blow in succession, so that those at the bottom of the spike have withered before those at the top are unfolded. Plantain blossoms in this manner. In other plants the flowers are crowded still more closely around the peduncle, and form an ear: such is the mode of flowering of corn and grasses; in others, they grow in clusters or irregular bunches like the vine. In many trees the peduncle assumes the form of a spike, *articulated* with the branch, and covered with the remains of degenerated bracteas, resembling scales, under each of which a flower lies concealed: the hazel, the willow, the alder, and the hornbeam, blossom in this manner.

Emily. I have paid so little attention to the manner of flowering of plants, that I was not at all aware they afforded so great a variety.

1155.—What is the involucrum, and the receptacle? 1156.—What is a cyma? 1157.—And what is a racemus? 1158.—How does the plantain flower? 1159.—How do corn and grasses? 1160.—How does the vine? 1161.—How do the hazel, the willow, the alder, and the hornbeam?

Mrs. B. I am far from having enumerated them all, for every different mode in which the pedicels diverge from the main stem, and which produces a different arrangement of flowers, bears its own peculiar name; but the whole is included in the term *inflorescence,* which expresses the various modes in which the stem of a flower is divided, and, consequently, the arrangement of the flowers upon it.

Plants blossom at regular periods; varying, however, according to the temperature of the country in which they grow, and the vicissitudes of the season. Linnæus formed a register of the season of flowering of different plants, which he called the Calendar of Flora, but no allowance being made for these modifications, it is very imperfect.

Emily. I have observed that there are some trees which regularly blossom earlier than others, of the same species and in the same situation: whence does this arise?

Mrs. B. It is not ascertained: but as every peculiarity of an individual plant is preserved when it is propagated by layers, slips, or grafts, advantage has been taken of this anomaly to produce early vegetation. Mr. Knight, by carefully selecting those potatoes which first sprouted for replanting, obtained in the course of a few years plantations of potatoes very considerably earlier than the usual season.

In hot climates the fig-tree produces two crops of fruit: and it is in some countries necessary to accelerate the ripening of the first, in order to leave time for the second to come to maturity, in due season. With this view, the peasants in the isles of the Archipelago, where this fruit abounds, brings branches of wild fig-trees in the spring, which they spread over those that are cultivated.

Emily. This is, no doubt, the same process as that of the fructification of the palm-trees in Persia.

Mrs. B. It was long supposed to be so; but it is now ascertained that the cases are quite different, the only use of these wild branches being to serve as a vehicle to a prodigious number of small insects, called cynips, which perforate the figs in order to make a nest for their eggs,

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1162.—By what term are the further varieties of flowering expressed? 1163.—What is said of the periods at which plants blossom? 1164.—In what manner did Mr. Knight cause potatoes to become unusually early? 1165.—What is said of the fruit fig-trees in hot climates? 1166,—Of what use in ripening the fruit were the branches of wild fig-trees?

and the wound they inflict accelerates the ripening of the fruit nearly three weeks.

Emily. Does the insect produce this effect by the injection of some stimulating fluid into the wound it makes, or is it owing to the growth of the eggs it deposits?

Mrs. B. The precocity does not appear to result from either of these causes: it is, indeed, not well known; but I should think may probably result from the punctures of the insects, impeding the free course of the sap, and producing, like the annular section, an accumulation of sap in those parts, which, by affording additional nourishment to the neighboring buds, accelerate their developement.

Have you not observed that fruits which are worm-eaten ripen earliest?

Emily. Yes; but I thought that the worms attacked those which were first ripe.

Mrs. B. I do not allude to the external attacks of worms and insects, but to the maggot born and bred within the fruit; and the nest of eggs, whence it drew its existence, was in all probability the cause of the precocity of the fruit.

Means may also be taken to retard the period of blossoming: too much nourishment is injurious at that season, and sometimes wholly prevents it. Much water is also prejudicial: the water is drained from the rice plantations when the rice is in flower; and the watering of gardens should be diminished. Snow late in the spring has, in mountainous countries, been known to retard the blossoming of corn till the following year.

It is remarkable that the conveyance of plants from one country to another appears to accelerate the period of flowering; for plants brought from foreign climes blossom earlier than usual, the first year of their emigration.

Caroline. That is very singular. Can it be owing to the excitement produced by the motion of the carriage?

Emily. May it not rather be attributed to the total cessation of vegetation during the journey, when the plant is confined by packing, and the consequent re-action which takes place on its being replanted?

1167.—By what means did these insects hasten precocity? 1168.—Why does wormy fruit ripen sooner than that which is sound? 1169.—By what means is the period of blossoming sometimes retarded? 1170.—How does moving plants from one country to another effect the period of flowering? 1171.—How do Caroline and Emily account for this?

Mrs. B. It is a point very difficult to explain. It frequently happens that, after blossoming, the fruit perishes from debility. An annular incision of the bark (which you may recollect arrests the cambium in its descent) increases the vigor of the blossoms by affording them more nourishment; but the ring, when made for this purpose, should be very narrow, in order that the upper and under edges of the severed bark may re-unite when this superabundance of food is no longer required in the upper part of the plant. M. Lancris makes the ring of such narrow dimensions, that the separation of the bark, lasts only during the flowering of the plant; at the end of which period, the protuberance at the upper edge of the bark having swelled out, till it reached the lower edge, and being still soft, the contact and gentle friction produced by the continuance of its swelling occasions it to burst: it then amalgamates with the lower edge, when the wound is healed, and the general circulation restored.

Caroline. That is to say, that the upper edge of the barb grafts itself upon the lower edge?

Mrs. B. Precisely so. This operation has been performed on the vine with some success; but these experiments have not been sufficiently extensive for their general results to be relied on. Its effect on fruit-trees, we have already observed, is very precarious: the branches of fruit-trees not being completely lopped every year, like those of the vine in vineyards, they are liable ultimately to suffer from the derangement of the circulation. It answers better with fruit-trees whose seeds are pippins, such as the apple and the pear, than with such as have stones and kernels, like the peach and the apricot, because, when the incision is made, the latter exude a gummy juice, so that they are liable to lose more than they gain by the operation.

There is another cause which frequently prevents the fruit from being formed. It is when water falls upon the stamens: this makes them burst before the due season, and the pollen, instead of being shed upon the pistil, is

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1172.—What was done by Mr. Lancris in relation to this subject? **1173.**—With what success have these experiments been made on vines? **1174.**—And with what success on fruit trees? **1175.**—What comparison is made between different kinds of fruit trees in reference to these experiments? **1176.**—When water falls on the stamen how does it affect the fruit?

lost. Rain, and even heavy mists, the latter of which, still more than the former, insinuates itself into the flower, very frequently produces this effect.

Caroline. But all blossoms are exposed to mists and showers: how then can any fruit be set?

Mrs. B. It is evident that Nature has decorated plants with a much greater number of blossoms, than she designed to convert into fruit, for the plant would have no means of bringing so great a quantity to maturity. Look at an apple or a cherry tree in blossom, and you will observe, that were every flower to produce a fruit, not only would it be impossible for the tree to nourish so great a crop, but even its branches would be unable to sustain them. Therefore, though every shower may destroy, or, rather, prevent the formation of a quantity of fruit, it would require heavy and continued rains to prove fatal to the whole. This, however, sometimes happens, particularly to the vine, which in wine countries is a very serious calamity.

I have still some further observations to make on flowers, but I think you have learnt as much to-day as you can well remember; we will, therefore, reserve what remains to be said on them till we meet again. In the mean time you may refresh your memory on what I have taught you by examining the drawing [Plate I.] in which the various organs of a plant are delineated in the representation of a pea.

The second drawing [Plate II.] represents a plant of the class of Monocotyledons of the lilaceous family, in which it is a disputed point whether the colored part of the flower is a corolla or a calyx.

Emily. It has, surely, much more the appearance of a corolla composed of six petals, than of a calyx consisting of six folioles. One of these two organs, then, is wanting in this family?

Mrs. B. In order to avoid error by deciding which of them it is, botanists call the colored part of a flower of this description a *perigone* or *perianth*, composed of one or more pieces; that of the tulip has six.

1177.—What question does Caroline ask concerning the effect of water on the production of fruit? 1178.—How does Mrs. B. answer it? 1179.—What does Plate I represent? 1180.—How is it explained? 1181.—What does Plate II represent? 1182.—How is that explained?

CONVERSATION XVIII.

ON COMPOUND FLOWERS.

Caroline. I have been studying your drawings, Mrs. B., and imagined that I understood them perfectly; but when I attempted to make out the several parts on a real flower, I am sorry to say that I found myself quite at a loss.

Mrs. B. What flower did you choose for this purpose, my dear.

Caroline. I was, perhaps too confident of my powers of discernment, for I selected one that had a totally different appearance from the pea or the tulip: it was a China Aster. I made out a calyx and a corolla, but the rest was all perplexity.

Mrs. B. You have fallen into an error which many botanists have done before you: you took the China Aster for a single flower, whilst it is, in fact, an assemblage of flowers, called in botany a *head.*

Here is a China Aster I have just gathered: let us examine it. [See Plate III.] The stem or peduncle is terminated by what *you* call a flower, and what I *call* a head of flowers. The extremity of the peduncle, you see, expands into a white disk, called a receptacle analogous to the receptacle of the umbel, and in this all the florets are inserted: it is not only the basis on which they rest, but serves them also as a magazine of food. In the China Aster it is flat, but in many other plants of the same family it is more or less convex: it is sometimes as thin as a sheet of paper, as in the *Scorzoenera;* at others, it is very fleshy, as in the artichoke.

Emily. Is it that internal part of the artichoke on which the choke rests, and which is so good to eat?

Mrs. B. Yes. Around the receptacle of the China Aster you see there are a considerable number of small leaves, or bractæ.

Caroline. That is what I supposed to be the calyx.

1183.—With what success did Caroline examine the plates? 1184.—Into what error did she fall? 1185.—What is illustrated in Plate III? 1186.—How is it described?

Mrs. B. It is a very natural mistake. It is, indeed, a sort of calyx common to the whole head; but as each floret has its separate calyx (and a calyx of so peculiar a nature as not to be overlooked,) this common calyx is distinguished by the name of involucrum, analogous to the involucrum which surrounds the *receptacle* of the umbel.

Emily. There seems to be a considerable resemblance between the umbel and the head of flowers?

Mrs. B. That is very true. If you conceived the branches of an umbel to be so extremely short that they could not be distinguished, the umbel would be similar to a head; and this is exactly the case of the *Eryngiums.*

Emily. The involucrum of the China Aster differs, however, in one respect from that of an umbel, the bracteas of which it is composed being much more numerous, and disposed in several rings or whorls around the stem.

Mrs. B. That is the case with the greater number of compound flowers, but it is not universal; for in the Salsafy (*Tragopogon,*) the *Orthonna*, and several others, the bracteas, or, as they are more commonly called, the folioles of the involucrum, are placed in a single ring. When disposed in several rings, they are sometimes equal; at others, vary in size: they are sometimes curled up; at others spread out. Some are soft, others scaly; and there are some which terminate in a species of thorn or prickle, as in the thistle. These varieties in the nature of the folioles serve to distinguish the numerous class of *heads of flowers*, which constitute no less than one-twelfth part of the vegetable kingdom.

Caroline. It is then, indeed, very necessary to make acquaintance with so numerous a body of plants. But you have mentioned both compound flowers, and flowers growing in a head:—are these terms synonymous?

Mrs. B. Certainly not; and I am obliged to you for reminding me of a want of accuracy.

All flowers which shoot in numbers from a common receptacle, either flat, or slightly elongated, are called *heads.*

1187.—Into what mistake does Caroline fall? 1188.—Under what circumstances would the umbel be similar to a head? 1189.—In what respect does the involucrum of the China Aster differ from that of an umbel? 1190.—How do the bracteas vary in different flowers? 1191.—What portion of the vegetable kingdom may be thus distinguished? 1192.—What flowers are called heads?

The flowers, analogous to leaves without petioles, are called sessile ; such are the Scabiosa, and many others.

Now, amongst this extensive class, there is one family distinguished from all the rest by the cohesion of their anthers, so as to form a tube around the style, and it is this peculiarity which constitutes the *compound flower*, or family of *Syngenesia;* and it is to this family that I shall more particularly direct your attention, as the China Aster, which we are examining, belongs to it.

You see all these little yellow parts in the centre of the head, and these violet leaves, which spread out around it, and which you took for petals : they are all of them distinct flowers.

Emily. Is it possible! Such a concourse of tiny flowers, so closely crowded together in the centre ; and these appear totally different from the violet-leaves, which you also call flowers.

Mrs. B. They are far from being so different in their structure as you would imagine from their appearance. In the China Aster, and in several other of the Syngenesia, the florets, though distinct, are not separated from each other by any intervening body ; but there are some plants of this family, such as the endive, the artichoke, and the camomile, whose florets are separated by a species of small bracteæ, which have been called palix or *chaff*, and which shoot up from beneath each floret. These bracteæ are sometimes of a scaly nature, and sometimes they assume the appearance of bristles or hairs. The choke of the artichoke, before the blossom is developed, is of this description.

Emily. The artichoke, then, is a compound flower ; and the only part of this plant that I am unacquainted with is its blossom, which is not developed when it is served at table. We there eat the receptacle and the most tender part of the leaves which compose the involucre, whilst the choke we carefully extract in order to avoid eating it.

Mrs. B. I advise you, when an opportunity occurs, to make acquaintance with the blossom. Let us now return

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1193.—What ones are called sessile? 1194.—What peculiarity constitutes the compound flower? 1195.—What is mentioned by Mrs B. of the China Aster which appears extraordinary to Emily? 1196. —How do the flowrets in the China Aster vary from those of the endive, the artichoke, and the camomile? 1197.—How are these bracteæ described? 1198.—What does Emily call the artichoke and what does she say of it?

to the China Aster: what I have hitherto told you relates more to the mode of flowering; but we will examine the structure of the flowers themselves. [Plate III.] Look at one of those little yellow florets in the centre of the head: with the assistance of this magnifying-glass you will be able to follow me as I describe the different parts. Observe, first, this white spot, which forms the basis of the floret: it consists of the tube of the calyx, and contains the ovary or seed-vessel to which it adheres.

Caroline. The external part of this tiny tube, then, is the calyx, and the internal part the ovary; but what are those little hairs which crown the tube, and grow from either the calyx or the ovary, I know not which?

Mrs. B. They proceed from the margin of the calyx, which assumes this singular appearance, because its natural growth, in the form of sepals or leaves, is impeded by the pressure of the adjacent florets.

Emily. And I conceive that the calyx may be stinted in its growth for want of food, as well as for want of room.

Mrs. B. That may also produce some effect in checking its growth; but the elongated form, which the edges of the calyx assume, must be chiefly owing to pressure. In some heads in which the florets are not so crowded as in the China Aster, the calyx wears a more natural appearance, being shaped like a cup, and is of a membranaceous texture: in others it resembles small scales: in the present instance, and in most compound flowers, it consists of a species of hairs, either separate or glued together. It was formerly considered by botanists rather as an appendage to the calyx than forming a part of it, and was distinguished by the name of tuft or *pappus*; and though this name applies literally only to hairs, it has been extended by analogy to all the various forms which this organ is capable of assuming.

Caroline. But this little feathery tuft appears much more ornamental than useful: it cannot, I think, in such a form, afford protection to the flower.

1199.—How does the China Aster appear as examined by a magnifying glass? 1200.—What question does Caroline ask concerning the tube of the calyx? 1201.—How does Mrs. B. answer it? 1202.—In different heads how does the calyx appear? 1203.—How was it formerly considered by botanists?

Mrs. B. The florets, being so close together, protect each other: the use of the tuft is to assist the fruit to disengage itself from the involucrum, and then to transport it to a distance; for the pappus remains upon the fruit after the blossom has fallen. There are some few compound flowers, the calyx of which is not at all elongated, and which, consequently, have no pappus.

Emily. How, then, does the fruit or seed disengage itself from the involucrum?

Mrs. B. When the tuft is wanting, the fruit is furnished with other means of separating itself from the parent-plant. Sometimes the recepticle rises up after the blossom is over, to force out the fruit; at others, the weight of the head, when it is mature, bends the pedunculus, and the seeds fall to the ground. Thus you see that every difficulty is foreseen and obviated in the admirable structure of which I am endeavoring to give you a mere outline.

Caroline. You speak sometimes of the fruit, and sometimes of the seed, which the tuft wafts away: do you mean to use these terms indifferently, or have they each of them a distinct meaning?

Mrs. B. I was not quite correct in so expressing myself; but the error was very trifling, as you will perceive, when I have explained the difference to you. I said that the small body, to which the tuft was attached, was composed of the ovary and the calyx. The ovary contains a single seed, which has its own particular covering, called Spermoderme. Thus the single seed of each little flower is enveloped in three integuments, adhering to each other—the calyx, the ovary, and the spermoderm. In some compound flowers, these three integuments are distinctly seen; but in others they are only supposed to exist by analogy, without being actually visible. These three integuments, soldered together, form a peculiar species of fruit, which was formerly called a naked *seed*, but is now distinguished by the name of *Achenium*. In some families (such for instance, as the *Epilobiums* and the *Apocinums*,) small feathery tufts grow within the germen, and

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1204.—What is the use of the tuft? 1205.—What flowers have no pappus? 1206.—If they have no pappus, how does the fruit or seed disengage itself from the involucrum? 1207.—With what is the single seed of each little flower enveloped? 1208.—What was formerly called the naked seed?

are attached to the seed. These tufts bear the name of *Coma*, and serve the same purpose as the pappus, though their origin is different. But we are digressing from our China Aster.

Emily. Pray let us return to it; for it has become very interesting, since I have learnt how much there is in these little things which you call florets.

Mrs. B. Above the ovary, and within the pappus, you may perceive a yellow tube, terminated by five small teeth; this is the corolla. If you slit it up with the point of a penknife, and look very close, you will see five little stamina: they have each their filament which appear to grow out of the tube of the corolla, and each of these filaments is terminated by an anther.

Caroline. I can see only one anther.

Mrs. B. Because the five anthers adhere together, so as to form a cylindrical tube, through which passes the style, the extremity of which spreads out into two small branches. It is this tube which constitutes a characteristic distinction of the compound flower. The five anthers, of which this tube is composed, open internally by two small slits. The style is also furnished with a peculiar species of stiff hairs, called *sweeping hairs;* because they are designed to sweep the pollen from off the anthers, so as to make it fall upon the stigma.

Emily. How wonderful that a little yellow atom, which I hardly looked at, should contain so great a variety of curious organs!

Mrs. B. The more you study nature, the more beautiful and magnificent it will appear. But we have not yet done with the China Aster. You understand the structure of the yellow central florets; but the purple ones, which form the circumference, are very different.

Caroline. In appearance, certainly, they are; for they look exactly like long narrow flat leaves.

Mrs. B. Pull out one of these violet leaves, and you will see that the extremity, by which it is attached to the receptacle, is not flat, but round and hollow, in the form

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1209.—What is the corolla, and what will be seen if slit up with a knife? 1210.—What is said of these stamina? 1211.—What constitutes the characteristic distinction of compound flowers? 1212.—How are the sweeping hairs situated, and why are they so called? 1213.—If one of the wild leaves of the China Aster is pulled out, what will be seen?

of a tube. Suppose it be an elongated tube, slit open lengthwise and spread out, and you will form a tolerable idea of this species of corolla. These are called *ligulate florets; ligula* being Latin for a strap: hence they frequently bear the name of strap-shaped florets.

Caroline. At the upper extremity there are five small teeth, like those of the yellow tubes.

Emily. But here, Mrs. B., is another China Aster, in which there are no yellow florets; the head is entirely composed of these flat violet florets, which we took for petals.

Mrs. B. This is a double China Aster. All its florets have undergone the change which in general takes place only with those situated at the circumference of the head; and you have here a proof of the two sorts of florets being of the same nature, since they are susceptible of being transformed from the one into the other. If you examine the flower attentively, you will see that the ligulate florets have no stamens, and even the style often appears imperfect; so that florets of this nature yield no seed, and when a head is entirely composed of them, it is incapable of propagation.

Caroline. Yet here is a scorzonera which has only flowers of this description, and it produces seed?

Mrs. B. I will explain to you whence this difference arises. Compound flowers exist in three different states: —the head is sometimes composed entirely of tubular florets; the artichoke and the thistle are of this description: they are called flosculous, and, with some few peculiar exceptions, all the florets yield seed. A second state is when the head is composed entirely of ligulate florets, having stamens and styles; such as the double China Aster, you have just observed: these form the class called *Ligulate*, or, as they are sometimes, though less properly, called, *Semi flosculous.* The scarzonere and the endive belong to this class, and all the florets yield seed. In the third state, the florets in the centre of the head are tubular, and those at the circumference flat or

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1214.—What are ligulate flowers, and whence do they receive their name? **1215.**—In viewing a double China Aster, of what does Mrs. B. tell Emily that she has proof? **1216.**—If the flower is examined attentively what will be seen? **1217.**—In how many different states do compound flowers exist? **1218.**—What is said of the first state and what ones belong to it? **1219.**—And of the second and what ones belong to this class?

ligulate: these are denominated *Radiate*. The dahlia, the aster (including the China Aster,) the camomile, the daisy, and many other plants, are comprehended in this division. The central florets generally yield seed, while the laternal ones are barren. These varieties of structure, combined with those which exist in the receptacle, the involucrum, and the pappus, have enabled botanists to separate and divide into classes the numerous compound plants which are spread over the face of the globe. There is also a fourth state of compound flowers, in which the corolla is divided into two lips; they are called *Labiate florets*. But I shall not enter into any details on this class, as it is found only in America, and is very rare in the botanical gardens of Europe.

Emily. I am glad that you spare my memory; for I fear I shall have some trouble to recollect all you have taught me concerning those which grow in Europe.

Mrs. B. I assure you that I have endeavored to make the subject as easy as I possibly could, and have omitted many difficult parts; but in this case, as in every branch of botany, you will understand clearly, only by seeing with your own eyes. Analyse the compound flowers you meet with; and when you have examined a few, you will comprehend them better than all my explanations will enable you to do. I do not pretend to make you adepts in botany; I merely wish to direct your attention to the observation of the works of Nature: they will speak for themselves, and in a language far more eloquent than I possess.

CONVERSATION XIX.

ON FRUIT.

Mrs. B. It is now time for us to take leave of flowers, and turn our attention to the fruits which they produce; in which state the seed may be considered as entering into a second stage of existence.

1220.—And of the third, and what ones are comprehended in this division? 1221.—What is a fourth state of compound flowers? 1222.—How may one be enabled well to understand this subject? 1223.—When does the seed enter its second stage of existence?

After the flower has performed its office of fructifying the seed; the petals, and every organ which is not destined to become a part of the fruit, wither and fall off. In the mean time, the ovary grows, and gradually assumes the appearance of a fruit.

Emily. Is the fruit, then, formed from the original little leaf which so carefully guarded the seed when the flower was in blossom, and which you called a carpel?

Mrs. B. Yes; when it assumes the form of fruit, it is frequently called by botanists *pericarp.*

Caroline. But I suppose it retains the name of seed-vessel, since it contains the seed in the fruit as well as in the flower?

Mrs. B. Certainly. Now let us take, for example, one in which the form of the original leaf is not wholly obliterated—this pod of a pea, for instance: you may plainly see that it consists of a leaf doubled over the seeds, with its edges united.

Emily. This pod, which is very young, is almost flat; but here is a larger one, which is become convex, in order to make room for the growth of the peas; and I perceive that the older it grows, the more it loses the form and appearance of a leaf.

Caroline. In shelling peas, I have observed that the pod readily opens where the edges of the leaf have been soldered together; but if you attempt to sever the pod at the opposite seam, which I suppose forms the midrib of the leaf, it is much more difficult.

Mrs. B. You are mistaken there, my dear; for, in shelling peas, the pod is opened by splitting asunder the midrib of the leaf. When the pod is ripe, this rib opens of itself, and the opposite suture or seam, formed by the soldering of the edges of the leaf, also gives way; so that the pod is separated into two halves or valves, and the seeds detach themselves and fall to the ground. This is a natural mode of opening, for the purpose of shedding their seed, which is common to a great number of pericarps: it is called *dehiscence.*

1224.—How is the change described? 1225.—What is the pericarp? 1226.—For what purpose does Mrs. B. examine the pod of a pea? 1227.—What mistake does Caroline make concerning it? 1228.—How does Mrs. B. explain her mistake? 1229.—What is *dehiscence?*

Caroline. Then the peas, which I thought had been attached to the midrib of the leaf, must grow from its margin: that seems very singular. Is there any instance of leaves, in their common state, bearing seeds thus?

Mrs. B. Yes; a leaf has been discovered (the *Bryophyllum*) which has this extraordinary property: it bears germs, susceptible of becoming young plants, and these are situated on its margin, like the seeds in a carpel. The same structure is found in the *Malaxis paludosa,* a little plant, growing occasionally in bogs in this country.

Caroline. Well, it is not very difficult to comprehend that a leaf may be converted into a pod, which you botanists dignify with the name of fruit; but I cannot conceive how you can metamorphose a leaf into what we ignorant people call fruits; such as an apple, a cherry, or a plum.

Mrs. B. With a little farther explanation, I hope I shall be able to accomplish this. Do you recollect the structure of a leaf?

Emily. It has a smooth upper surface, and an under surface more porous, of a rougher texture, and generally downy or hairy. Between these surfaces lies the pabulum, a softer body, consisting of an expansion of the cellular system, and this is traversed and intersected by the fibrous vessels which form the ribs of the leaf.

Mrs. B. Extremely well. In the pea-pod these several parts are distinguishable. The leaf is doubled upon its upper surface, so as to render the under surface external.

Emily. The most porous surface must, of course, form the out side of the pod, otherwise the stomas could be of no use.

Mrs. B. This is the case not only with the pea but with all carpels. The external surface takes the name of *epicarp:*—the upper surface of the leaf forms this thin delicate skin, which lines the interior of the pod: it is called *endocarp;* and the pabulum of the leaf is this soft intermediate layer, which is denominated *mesocarp.*

1230.—What is said of the Bryophylum, and what other plant is there of a similar character? 1231.—What is Caroline unable to comprehend in relation to this subject? 1232.—How does Emily here describe the leaf? 1233.—How is this description applicable to the pea-pod? 1234.—What is called the epicarp—the endocarp—and the mesocarp?

Caroline. Oh, what hard words to remember Mrs. B.!

Mrs. B. You will, perhaps, be able to retain them more easily if I explain their derivation: *carpos* is the Greek word for fruit, and *epi* for upon or over.

Caroline. That clears up the whole difficulty: for it is easy to understand that *epicarp* signifies the outside skin which is *upon* the fruit; *endocarp* the inside skin; and *mesocarp*, no doubt, means the middle substance between the two. Now, if you will be so good as to tell me the derivation of the word *peri*, I shall not forget the meaning of pericarp.

Mrs. B. *Peri* signifies about or around: so pericarp means about or around the fruit. According to this definition, the seed alone is considered as the fruit; but, in the usual acceptation of botanists, the pericarp itself constitutes the principal part of the fruit.

A leaf, forming a carpel or pericarp, may be folded in a variety of ways, either cylindrical, or like a cornucopia, or doubled a little convex like a pod; but, however diversified the form of the fruit, it results always from the manner in which the leaf was originally folded, when it first budded.

Now, into what sort of fruit, do you wish that I should convert one of these pericarps?

Caroline. You speak with the same confidence, Mrs. B., as if you were going to perform the metamorphosis with a fairy's wand; and make me expect to see it accomplished, with the same facility that the pumpkin was converted into a coach for Cinderella. However, I shall endeavor to increase the difficulty of your task, by making choice of a fruit which bears no kind of resemblance to a leaf—a peach, for instance. Will it not require the utmost effort of your art to effect this transformation?

Mrs. B. Far from it; for the peach is one of the most simple of fruits: it resembles the pea-pod, in being composed of a single carpel, but it is still less complicated, for the carpel contains but one seed—the kernel within the stone. The skin is the epicarp. Do you not

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1235.—How is the meaning of these terms explained from their derivation? 1236.—In the same way how is the pericarp? 1237.—In what different ways is the pericarp folded? 1238.—What fruit does Caroline select for an illustration? 1239.—How does Mrs. B. explain the formation of the peach from the leaf?

recognize the hairy cuticle of the under surface of the leaf in the downy skin of the peach? Then the cellular texture of the pabulum, absording a great quantity of sap, and swelling out as it grows, forms the fleshy substance of the fruit:—this is the *mesocarp*. Finally, the upper surface of the leaf being, in a great measure, deprived of moisture, and starved, as it were, by the voracious appetite of the mesocarp, its fibres contract, become tough, then indurated, and are at length converted into a shell or hollow stone, which affords, most secure shelter for the seed:—this is the *endocarp*.

Caroline. What a very curious transformation! Every vestige of the ribs of the leaf is obliterated in the fruit; but traces of contraction of the endocarp are discernible in the seams and wrinkles with which the stone is covered.

Emily. There are also indications of its being composed of two valves, for a sharp instrument will split it open, and divide it into two parts, and, when it is diseased, it separates of itself. Then the curved indenture, which runs along the peach on one side, I think, points out the seam of the carpel. And pray, Mrs. B., are all stone-fruits formed in the same manner?

Mrs. B. Yes, they are. This class of fruits is distinguished by the name of *Drupe* or *Drupa:* among these you will, perhaps, be surprised to hear, that the almond and the cocoa-nut are classed.

Emily. They certainly bear very little apparent resemblance to fleshy stone-fruits, being wholly destitute of a fleshy mesocarp.

Mrs. B. In these dry drupes, the mesocarp assumes the form and texture of coarse thready fibres, which form the external covering of the nut: the endocarp is the hard woody nut, and the smooth skin with which it is covered is the epicarp.

Caroline. Who would ever have imagined that the flesh of the peach, so delicate and luscious, and the coarse fibres which enclose the almond, had both a similar ori-

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1240.—What makes the epicarp, and what the mesocarp? 1241.—What makes the endocarp, and how is it formed? 1242.—How does the peach stone resemble a leaf? 1243.—By what name is this class of fruits distinguished, and what others are included in it? 1244.—In these drupes, what makes the mesocarp, the endocarp, and the epicarp?

gin! I suppose, then, that it is the almond which absorbs the chief part of the nourishment, for the whole of the pericarp is dry and meagre.

Emily. Were fruits not so treacherous in their appearance, I should conclude that the apple and the pear derived their fleshy substance, like the peach, from the swel ling out of the mesocarp; but I have so often been mistaken in my conjectures, that I make the inquiry with diffidence?

Mrs. B. You are right not to be too confident; for the apple and pear are quite of a different description from the drupe. But do not let us proceed too fast, and by degrees I hope I shall be able to make you comprehend them all. I began by selecting the most simple cases, in order to be well understood: we must go on upon the same plan; for in natural science we cannot, as in chemistry, make experiments which gradually lead us from the simplest to the most compound combinations; but Nature makes these experiments for us, and our business is onl to arrange the combinations she exhibits in methodica order. We have hitherto considered fruits formed of a single carpel; but it is not difficult to concieve that a fruit may be composed of several carpels. Take, for example, this Pœony: it consists of a number of carpels, each of which exactly resembles a pod. You recollect my telling you that the pistil of a flower was commonly formed of several carpels: such flowers will produce fruits with a similar number of carpels.

Caroline. Oh, yes; and I recollect your saying that this was the case with the apple and the pear.

Mrs. B. A little more patience: we are not yet arrived at the apple and the pear.

Emily. But cannot you show us some other fruits similar to that of the pœony? for I see it is only by natural specimens that one can understand the curious transformation of flowers into fruits.

Mrs. B. It is very true, that it is necessary to observe the flower in order to understand the conformation of the fruit. Here is an *opocynum:* its flower bears two carpels,

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1245.—What does Caroline suppose of the almond? 1246.—What comparison does Mrs. B. make between experiments in chemistry and botany? 1247.—To illustrate what is the Pœony selected and what is said of it? 1248.—Why is it an apocynum and what is said of it?

which differ but little from a pod: these carpels are distinguished by the name of *follicles*. Here is another example: it is a variety of the cherry, which, instead of bearing a single drupe like the common cherry, bears several.

We will now proceed another step, and examine the raspberry: this fruit consists of a considerable number of small fleshy carpels, all of which result from a single flower. It resembles an aggregation of small drupes.

Emily. The number of carpels, then, I see offers no difficulty: a flower may bear one carpel, like the pea; or two, like the apocynum; or five, like the pæony; or a still greater number, like the raspberry.

Mrs. B. Now, examine this long narrow pericarp of the wall-flower: of what number of carpels do you suppose it consists?

Caroline. Of only one, for it is a pod similar to that of the pea or the bean;—but no, on opening it, I percieve that a thin partition runs down the middle, which divides it into two cavities, and that there is a row of seeds in each. This pod must therefore consist of two carpels growing together, so as to form but one fruit.

Mrs. B. Pericarps of this description are called *siliques*, not pods. The pod belongs to the *leguminous*, the silique to the *cruciform* family.

Emily. We have seen many instances of the organs of flowers being soldered together: the petals, for instance, are frequently united so as to form a corolla of a single piece; the stamens often cohere together by their filaments; the anthers are united so as to form a tube in compound flowers; and it is not more difficult to conceive that several carpels should be soldered together, and form fruits, having different cavities or cells for seed.

Mrs. B. You may consider it as a law of Nature, that the number of cells for seed contained in a fruit, implies the number of carpels soldered together in its formation. This law, however, admits of exceptions, which require some further explanation. The carpels, you allow, consist of folded leaves: if these reach to the centre of the fruit, the cells will be complete; if they reach but half way,

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1249.—What is said of the cherry? 1250.—And of the raspberry? 1251.—What discovery does Caroline make in examining a wall flower? 1252.—What is the difference between siliques and pods? 1253.—What are cases of the organs of flowers being soldered together? 1254.—What does Mrs. B. say may be considered a law of nature?

the centre will be hollow and empty; for the partitions formed by the folding of the leaves will only reach half way; of this the poppy is an instance. If the leaves be still less folded, they will spread out in growing, and the fruit, though composed of several carpels, will only have one cell: the melon is an example of this kind.

Emily. How, then, can you distinguish a fruit that has but one cell for seed, because it is formed but of one carpel, from a fruit that has but one cell, though originally composed of several carpels?

Caroline. I think I can explain that. When the fruit consists of one carpel only, the seed will be situated in a row on one side of the carpel; but when it consists of several carpels, there will be as many rows of seeds as there are carpels, since each carpel bears its row of seeds.

Mrs. B. You are right; but recollect that each row, though apparently single, is in fact a double row, the seeds being attached alternately to each valve of the carpel.

Well, now that you have seen and understood the result of the soldering of carpels together, and the effect of the leaves, of which they are composed, being more or less folded or curved inwards, you may readily conceive that such differences are sufficient to account for the various forms of fruits.

When the carpels are *verticillate*, that is to say, situated around a common axis, or a little column (called *columella,*) the division of the carpels often completely disappear externally, and the fruit assumes a spherical appearance; but if the convexity of the carpels be greater than that of the whole fruit, each carpel protrudes externally, forming a rib, such as those of the house-leek.

Emily. The shrub, which is dignified with the name of Pæony-tree, has the carpels of its fruit enclosed in a sort of membrane, which covers them completely.

Mrs. B. This membrane, according to the celebrated Mr. Brown, appears to be a prolongation of the Torus,

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1255.—Examples of what are the poppy and the melon named? 1256.—What question does Emily ask? 1257.—How does Caroline answer it? 1258.—What does Mrs B. say must be recollected? 1259.—When are the carpels said to be verticillate, and when they are what is the form of the fruit? 1260.—What is the consequence if the convexity of the carpels be greater than that of the whole fruit? 1261.—What is said of the carpels of the Pæony-tree?

or base of the stamens, which grows over the carpels, and, in some instances, adheres to them; but this species of conformation is very rare. One that is much more common, but also more complicated, is when the carpels not only cohere together, but are also soldered with the calyx; so that when the blossom falls, the fruit which grows is composed of the carpels and the calyx, forming a single body.

Emily. This must produce a fruit of a very singular appearance.

Mrs. B. Not so much so as you imagine; for the apple and the pear are of this description. This mode of growing can be easily understood when the fruit is traced from its primitive existence in the flower; but I can give you an infallible test to know whether the fruit, when already grown, is of this description. You see the eye at the top of this pear: it is formed by the remnants of the sepals, or leaves of the calyx; and whenever you see such an eye at the summit of a fruit, you may be assured that it consists of the carpel and the calyx soldered together. All fruits whose seeds are pips, are of this nature, and are distinguished by the name of *Pome.*

Emily. The quince, I am sure, then, consists of the calyx soldered to the carpels, for it has a very large eye: but is the medlar also of this description?—it has a considerable opening at the top, somewhat resembling an eye.

Mrs. B. Yes; and the aperture results from the calyx not completely covering the carpels: these, therefore, are visible between the teeth, or indentures, which terminate the calyx.

Emily. I see that the metamorphosis of a flower into a fruit is in many cases a very complicated affair, and not so easy to understand as I had imagined from your first explanation. Is it the calyx which forms the skin, and the pericarp the flesh of the pome?

Mrs. B. It is difficult to distinguish these organs, when cohering together. The calyx, however, being external, must naturally form the skin of the pome; part of it may

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1262.—What one is mentioned more common although more complex? 1263.—What fruit is of this description? 1264.—How may it be known if the carpel and the calyx are soldered together in the fruit? 1265.—What fruit is of this nature and what is it called? 1266.—From what does the opening in the top of the medlar result? 1267.—Of what is the skin formed?

also enter into the composition of the flesh, together with a portion of the pericarp. The heart, or core of the pome, consists of the endocarps of five carpels, each containing two seeds or pips.

Emily. The orange has no eye; otherwise I should have thought it had been a fruit of a similar construction.

Mrs. B. Far from it: the orange is a pulpy, not a fleshy fruit, like the *pome* or the *drupe.* Now pulp does not, like flesh, result from the growth of the mesocarp, but is a peculiar succulent substance, situated inside of the carpels: those of the orange consist of the quarters into which the fruit may be easily divided when the rind is pealed off, and the seeds are imbedded in the pulp contained within them.

Caroline. True: they are not lodged in a core, like the apple or the pear; nor in a shell or nut, like the peach or the plum. But might not a fruit have both flesh and pulp?

Mrs. B. Yes; the quince is an instance of this combination: the flesh is, like that of the pear, situated outside the core or cells containing the seeds, and within those cells the quince contains pulp; but this species of complication is not common.

Caroline. And pray, under what head do you class those fruits in which the seeds are promiscuously situated, such as the gooseberry, the currant, and the grape?

Mrs. B. They are distinguished by the name of ***Bacca***, or berry: in these the mesocarp is soft and succulent. Although the seeds are attached to the endocarp, yet the latter is obliterated when the fruit is ripe. A strawberry is not properly so called, because it does not belong to the class of berries. It consists of a fleshy substance, formed by the expansion of the summit of the pedunculus, in which the several parts of the flower are inserted, and which we have called the *torus.* The small grains which you see upon its surface are so many little carpels, each of which contains a seed.

Caroline. They are so small and dry that they look like naked seeds.

1268.—Of what does the heart, or core of the comb consist? 1269.—What is said of the orange? 1270.—And of the quince? 1271.—Under what head are classed the gooseberry, the currant, and the grape, and what is said of them? 1272.—What is said of the strawberry?

Mrs. B. The pericarp fits closely to the seed, so that they seem to form but one body; but they may, thus united, be considered as so many distinct little fruits, imbedded in the soft substance of the torus.

Caroline. They would be very little appreciated as such, were it not for the delicate flavor of this soft substance.

Mrs. B. These little grains, though dry, are analogous to the small fleshy spherical bodies which form the raspberry; and the white conical substance which remains upon the calyx of the raspberry, after the fruit is pulled off, is analogous to the fleshy substance of the strawberry; for they both result from the growth of the torus.

Caroline. With this difference: in the one it is the torus; in the other, the berry, or true fruit, which is good to eat.

Emily. And is not the conical expansion of the torus, on which the raspberry grows, analogous to the axis or stalk which traverses the mulberry? For these two fruits bear a great resemblance to each other.

Mrs. B. You are falling into an error to which every one is liable who judges from the appearance of the fruit without having previously studied the flower. If you examine the blossom of the mulberry, you will see that it consists of several small sessile florets, disposed around the axis; that each of these, after the blossom has fallen, forms a distinct fruit, consisting of the carpel and the calyx: these fruits being fleshy, and situated so near to each other as to come in contact in growing, cohere together; so that a mulberry, which is in fact an aggregation of several different fruits, proceeding from as many different flowers, wears the same appearance as a raspberry, which is the result of different carpels belonging to the same flower.

Emily. There are, then, if I mistake not, no less than four degrees of complication in the composition of a fruit.

First. Fruits formed by a single carpel, such as the pea or the peach.

1273.—To what are the little grains on its surface analogous? 1274.—And what in the raspberry is analogous to the fleshy substance of the strawberry? 1275.—If the blossom of the mulberry is examined, what will be seen? 1276.—Why has the mulberry the same appearance as the raspberry? 1277.—In the four degrees of complication in the composition of fruit, what is the first?

Secondly. Those formed by several carpels, the produce of a single flower, like the pæony and the raspberry.

Thirdly. Those formed of several carpels, surrounded by and soldered with the calyx, such as the apple and the pear.

Fourthly. Those formed by the aggregation of several fruits produced by different flowers.

Mrs. B. Your enumeration is perfectly correct. I will give you some further examples of the latter description. The cone of a pine or fir tree consists of an aggregation of fruits, produced by as many different flowers, having each a single seed: these flowers are separated from each other by bractæ, which remain after flowering: they grow tough and hard, and enclose each of the fruits as it were in a case, the aggregation of which forms the fir-cone.

Emily. This is a kind of fruit quite new to us; and the cone of the magnolia is, I suppose, of the same description.

Mrs. B. No; the cone of the magnolia proceeds from several carpels belonging to the same flower. The difference is very difficult to distinguish after the blossom is over, and the fruit formed; but is easily observed if the history of the fruit is traced from the period of blossoming.

Caroline. It seems to me to be very difficult to avoid error on so complicated a subject.

Mrs. B. I cannot deny it; and I will give you another instance of deceitful resemblance. Few things bear a greater likeness to each other than the Spanish chesnut (*castanea vesca*) and the horse chesnut (*æsculus hippocastanum;*) yet the horse-chesnut is simply a seed, while the Spanish chesnut is a fruit, consisting of two or more seeds, each of which has its separate envelope, under the form of a reddish-brown skin. The shell of the horse-chesnut is a capsule produced by a single flower. The prickly covering of the Spanish chesnut is an involucrum, which surrounded the several flowers. You see, therefore, that it is very difficult to decide upon the nature of the fruit without having studied the flowers whence it derives its origin.

1278.—What is the second? 1279.—What is the third? 1280.—What is the fourth? 1281.—What is said of the cone of a pine or fir tree? 1282.—And of the cone of the magnolia? 1283.—What other instance of deceitful resemblance does Mrs. B. mention? 1284.—What is said of the shell of the horse chesnut and the prickly covering of the Spanish chesnut?

Are you desirous to have another curious example of the cohesion of fruits produced by different flowers? It is afforded in the pine-apple. This, which you have doubtless hitherto considered as a single fruit, is the result of the soldering of a number of small fruits, produced by sessile flowers aggregated on an axis, which is the stalk. These small fruits, being soft and fleshy, unite together; but traces of the different fruits are seen on the surface, each forming a small protuberance: the axis of the fruit terminates in a crown of leaves, which surmounts the whole.

Caroline. But where are the seeds?

Mrs. B. Cultivation, I have told you, tends to diminish the quantity of seed: in the pine-apple it makes them fail completely, so that the plant can be propagated only by the crown or by suckers. You may see towards the centre of the pine-apple the vacant cells in which the seeds have perished, and in which they are lodged in the wild pine-apple, whose fruit is less succulent and less highly flavored.

From the pine-apple and the mulberry you may conceive a very good idea of the fruit of the bread-tree, which supplies the inhabitants of the South Sea Islands with food. It may be compared to a very large mulberry, composed of aggregated fruits. When the seeds fail, which is the case in the Friendly Isles, the fruit grows to a prodigious size: when the seeds are perfected, it is in a great measure at the expense of the fleshy part, whose place they occupy, and the fruit is consequently inferior both in size and flavor. This is the case with the wild bread-tree (*Artocarpus incisia.*)

Emily. You have said that some carpels do not open to shed their seeds: how, then, can these sow themselves and germinate?

Mrs. B. Fruits, in this respect, may be divided into three classes.

First. Those which do not open, and which contain but one, or at most a very few seeds; such are the fruits of the gramineous family, and of compound flowers. They are distinguished by the name of *Pseudosperma*,

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1285.—What is said of the pine apple? 1286.—And of the seed of the pine apple? 1287.—In regard to the sowing and the germination of seeds, plants are divided into three classes—which is the first? 1288.—What is the second? 1289.—And what is the third?

which signifiies false seeds; because, though they assume the appearance of seeds, yet, being surrounded by their pericarp, they are in reality fruits, and in this state they are sown and germinate.

Secondly. Those fleshy fruits which do not open naturally; these in the course of time become rotten, and thus disengage their seeds.

Thirdly. Fruits which are not fleshy, and which contain a number of seeds, are collectively distinguished by the name of *capsular* or *dehiscent* fruits. These open naturally and shed their seeds, which are dispersed in falling, and thus have a greater chance of germinating.

Caroline. This classification of fruits is more easy to comprehend than the others.

Mrs. B. True, but it is much less important; for, instead of explaining the essence of things, it shows only the consequences. It is, however, far from being devoid of interest; but I shall enter into no further details: it is better to rest satisfied with the knowledge of a few principles, which I trust you will find no difficulty in applying to the different plants which may come under your notice. I can never sufficiently repeat, what my professor of botany has so often observed, that natural history can be learned but in a very imperfect manner in books; and that, in order to obtain a competent knowledge of objects, they must be studied in nature.

CONVERSATION XX.

ON THE SEED.

Mrs. B. Before we proceed to treat of the germination of the seed, we must examine its internal structure. A seed may be considered as a germ situated at the axilla of a leaf.

Caroline. Of that famous little leaf which performs so great a part in the flower and the fruit, and undergoes as many transformations as harlequin in a pantomine?

Mrs. B. No; the one I allude to is another little leaf, which adheres so closely to the germ as to form the coating of the seed itself: it is called the Spermoderm,

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1290.—What does Mrs. B. say of this classification? 1291.—What may we consider the seed?

from two Greek words, *sperma*, signifying seed, and *derma*, skin.

The spermoderm, like the pericarp, is composed of three coats.

Emily. Derived, no doubt, from the two surfaces, and the pabulum of the leaf, of which it is formed.

Mrs. B. Precisely. The external skin, called *Testa*, or *cuticle*, corresponds with the epicarp; the cellular coating, denominated *Mesosperm*, with the mesocarp; and the internal skin, called *Endopleura*, represents the endocarp.

When this leaf first shoots, it is hollow, and contains a nutritive juice called *Amnios:* the germ attached to its axilla, when fructified, begins to absorb this fluid: it takes the name of embryo; and is, in fact, a plant in miniature. In proportion as the amnios diminishes, the embryo fills out and occupies the vacant space: in the course of time it grows so large as to distend the spermoderm itself. Here is a very young bean: I slit open the spermoderm, and you see the embryo plant surrounded by the amnios.

Emily. But it is the miniature of a bean, not that of a plant.

Mrs. B. It is the cotyledons of the embryo plant which form the greatest part of this little bean: the radicle and plumula are enclosed within them, and are not sufficiently developed to be distinguished without the aid of a microscope. But here is a full grown bean, in which the embryo occupies the whole interior of the spermoderm, the amnios having been all absorbed. Now, if you separate the cotyledons, you will perceive the skeleton of the plant lodged between them, and making a slight indenture in either cotyledon.

Caroline. I see it perfectly; but it is not in the centre of the bean.

Mrs. B. No; it is situated at that end by which the bean was connected with the pod by a short pedicel. This spot is commonly called the eye or hilum of the seed.

1292.—From what Greek words is the term Spermoderm derived? 1293.—Of how many coats is it composed? 1294.—What are they called and to what do they correspond? 1295.—What is the Amnios? 1296.—Whence originates the embryo, in what proportion does it increase, and what is said of it as seen in a young bean? 1297.—By the aid of a microscope in the young bean? 1298.—What further appears in the full grown bean? 1299.—What is the eye of the seed, and what conveys nourishment to the embryo plant?

The pedicel conveys nourishment to the embryo plant. When the seed is ripe, this communication ceases, the pedicel withers and dries, and the seed detaches itself. This scar which you see on the testa, and which interrupts its uniform smoothness, is made by the rupture of the pedicel, and is always considered as the base of the seed; and you may still perceive the small aperture through which the nutritive juices passed into the seed.

Emily. But is not the embryo plant nourished by absorbing the amnios?

Mrs. B. Not wholly; for you must consider that it not only requires food for its immediate sustenance, but lays up a store of provision in its cotyledons, which is reserved for its future growth at the period of germination.

Caroline. I always thought that those little threads which fastened peas and beans to the pods were merely to prevent their rolling about in the shell; but now I see that it is necessary they should have a communication with the pod, for the conveyance of nourishment.

Emily. What vessels in miniature these must be! I know nothing more curious than the extreme, I may almost say the invisible, minuteness of some of the organs of plants.

Mrs. B. In some seeds, the whole of the amnios is consumed by the embryo plant; in others, the absorption of this liquid is only partial: the most fluid parts pass into the embryo, while the more solid particles, being probably too bulky to traverse such minute vessels, are deposited in the interior of the seed. This substance is, at first, of the color and consistence of the white of egg, and has thence acquired the name of albumen; but, as the seed approaches maturity, it coagulates, and adheres to the endopleur, lining it throughout with a white concrete substance, and, indeed, filling the whole of the space which is not occupied by the embryo plant. This is a resource afforded by Nature for the germination of seeds which have not a sufficient store of food in their fleshy cotyledons.

Caroline. But peas and beans are so well supplied by these cotyledons, that they are in no want of such resource.

1300.—What is said of the scar on the testa? **1301.**—Emily asks, if the embryo plant is not nourished by absorbing the amnios—what is the answer? **1302.**—How is the conversion of the amnios into the embryo, in different seeds described? **1303.**—What is albumen, from what does it derive its names, and what agency does it have in the formation of the plant.

Mrs. B. Very true: the whole of the leguminous and the cruciform family, as well as several others, have no albumen. But the gramineous family, which includes all the various species of corn and grasses, are in great need of this auxiliary; for not only do they belong to the class of monocotyledons, but their single cotyledon is so small, that, although slightly fleshy, it affords but very little nourishment. But let us seek for an example on a larger scale:—you have, I dare say, eaten the white substance which lines the shell of the cocoa-nut?

Caroline. Frequently: it has the consistence, and somewhat the taste, of an almond. This, then, is albumen; but what is the water that fills the cavity of the nut?—It cannot be the more fluid part of the amnios, as this, you say, is absorbed when the albumen is deposited.

Mrs. B. The seed of the cocoa-nut is very large, and the embryo plant very small; so that the latter cannot absorb the whole of the amnios, and it is the residue which constitutes the water of the cocoa-nut. Albumen, you will observe, does not, like the cotyledons, constitute a part of the embryo plant; it is merely a deposition of wood for its use. The embryo is in general much larger in seeds which have no albumen.

Caroline. Of course, such embryos carry their store of food about them, as a snail carries its house upon its back: they must therefore occupy more space; and, the whole cavity within the spermoderm being vacant, they have more space to occupy.

Mrs. B. All that is contained within the spermoderm, whether it consist of the embryo plant and albumen, or whether of the embryo plant alone, is called the nucleus, kernel, or almond of the seed.

Emily. The amnios, then, either in its entire substance, or a fluid secretion from it, is destined to feed the embryo plant, while the young seed is embosomed in the flower. The albumen and cotyledons afford a coarser sort of food, reserved for the future nourishment of the seed when it germinates.

1304.—What plants have no albumen? 1305.—What ones are in great need of it? 1306.—What is said of the seed, the embryo plant, and the amnios of the cocoa-nut? 1307.—In what seeds is the embryo the largest? 1308.—What is called the nucleus—by what other names is it called?

Mrs. B. So nature designed it, but art converts the greater part of this coarser sort of food into nourishment for a superior order of beings. In peas and beans it is the fleshy cotyledons that we eat; in corn it is the albumen of the seed which supplies us with bread.

Caroline. But in peas and beans it is the seed itself we eat, not the cotyledons?

Mrs. B. The cotyledons form the principal part of the seed; of those, at least, which have no albumen. If, instead of eating them when young, we allowed them to ripen and germinate, the pea and the bean would separate into two parts, and assume the form of cotyledons.

Emily. We then rob the young plant of its destined food?

Mrs. B. No doubt we do. If corn were not reaped, the grain would fall into the ground, and, there germinating, the albumen of the seed would be expended in nourishing the young plants; but when these plants struck root, the soil would be unable to maintain a crop so thickly sown: many seeds would perish for want of food, and the rest, being but imperfectly supplied, few or none would come to perfection. Man, therefore, deserves no reproach, even from the vegetable kingdom, when he scatters the seed in such quantity only as the soil can nourish, and reserves the remainder for his own use.

Emily. It appears to me surprising, that the embryo plant, after having been in an active state of vegetation while the seed remained within the flower and the fruit, should become, as it were, dormant when the seed is mature, and separated from the plant; nay, should often remain so for a long period of time.

Mrs. B. The principle of life, it is true, can be preserved in some seeds a great number of years; but what that living state is, which so nearly resembles death, we cannot explain. It is time, however, for us to rouse the inactive seed from its torpid state, and examine it, when it enters into a new existence, as a separate and independent being.

1309.—To what higher purposes is this nourishment converted, and what are instances of it? **1310.**—Caroline asks, if in peas and beans, we do not eat the seed itself—what is the answer to her question? **1311.**—If corn were not reaped, what would be the consequences to the vegetable kingdom? **1312.**—What appears surprising to Emily? **1313.**—What does Mrs. B. say of the principle of life in seeds? **1314.**—In what state does she now suppose the seed?

Emily. True; we have hitherto considered only the formation of the seed, and its growth in the flower and the fruit.

Mrs. B. Let us now, then, suppose it to have attained a state of maturity, and ready, when placed under favorable circumstances, to germinate. For this purpose the seed must first be detached from the parent plant.

Caroline. That is what we every day witness. The fruit, when ripe, drops from the tree; or the pericarps, when dry, burst open, and shed their seeds.

Mrs. B. Not always: some pericarps, we have observed, have no natural mode of opening; such is the nut, the amaranth, the pericarps of compound flowers, and those of gramineous plants. In the latter, the pericarp adheres so strongly to the seed, that they are confounded together, and cannot be distinguished. The seed is, in this case, inaccurately said to be naked; when ripe, it falls from the stem, inclosed in the pericarp, and, thus covered, sows itself in the ground.

Caroline. Then I think that seeds of this description should be called clothed, rather than naked.

Mrs. B. They are so, in fact; but as the pericarp is of a hard dry nature, and adheres closely to the seed, it is commonly considered as forming a part of it. Thus the seeds of corn and grasses are sown enclosed in their pericarps.

Emily. Then the pericarp, I suppose, rots in the ground, and the seed is left at liberty to germinate?

Mrs. B. The pericarp ultimately rots, but not until the germ has made its escape through a small aperture, which nature has provided for that purpose. That of a grain of corn is too minute to be seen with the naked eye; but you may probably have observed three openings of this description in the cocoa-nut, a seed of sufficient size for them to have attracted your attention. Through one of these the embryo escapes from its prison.

Emily. But the stem and the root cannot both shoot from the same opening, or they would both grow in the same direction?

1315.—What pericarps have no natural opening? 1316.—What is said of the seed and its pericarp in gramineous plants? 1317.—How are the seeds of corn and grasses sown? 1318.—How does the germ escape if the pericarp remains? 1319.—What is said of a grain of corn and the cocoa-nut in explanation?

Mrs. B. The radicle first sprouts from the aperture with the neck situated at its base; from this vital spot the plumula shoots upwards; but the young plant remains attached to the pericarp by the neck, until it has consumed the albumen of the seed, and is able to supply itself with food from the soil.

It is thus that monocotyledons are ushered into life. The germination of dicotyledons is somewhat different. The seed is not enveloped in its pericarp, and, when it begins to germinate, the spermoderme cracks and falls off; the cotyledons, commonly called the lobes of the seed, are split asunder by the stem which rises between them; but, like a careful parent, they follow their nursling at its entrance into life, and continue to supply it with food until its roots are sufficiently strong to perform that office. The embryo plant consists, then, of three parts: the *radicle*, or root; the *plumula*, or little stem; and the *cotyledons*, or seminal leaves, which make their appearance at the base of this stem.

The first and most essential circumstance requisite for germination is moisture; for a seed, in germinating, absorbs about once and a half its weight of water.

Emily. This is, no doubt, for the purpose of softening and dissolving the hardened contents of the cotyledons, and rendering them sufficiently limpid to pass through the minute vessels which convey them into the embryo plant.

Mrs. B. Yes; moisture is equally necessary, whether the germinating plant be fed by the farinaceous matter of the cotyledons or by albumen; for seeds, when ripe, you know, are perfectly dry, or if they contain any water, it is not in a state of liquidity, but solid, like the water of crystallisation in mineral salts. If seeds are deficient in moisture, they are, on the other hand, overladen with carbon, so that you must supply them with water, and free them from a portion of their carbon, to enable them to germinate. It is the great quantity of carbon which seeds require in ripening that exhausts the soil in which they grow.

1320.—How is the first germination described? 1321.—How does the germination in monocotyledons and dicotyledons vary? 1322.—Of how many parts does the embryo plant consist and what are they? 1323.—What is the first and most essential circumstance requisite for germination? 1324.—For what purpose is the moisture needed? 1325.—What effect on the carbon is caused by a deficiency of moisture? 1326.—What exhausts the soil?

Caroline. But for what purpose do they require this accumulation of carbon, since they must part with it in order to germinate?

Mrs. B. Carbon is a great antiputrescent, and is necessary to prevent the seed from rotting previous to being sown. Some seeds are, through its influence, capable of being preserved several centuries; while others, which are but scantily supplied with it must be sown as soon as ripe. And in seeds which have not acquired a due supply of this preservative, the principle of life is extinguished before they separate from the parent-plant.

Emily. With a view of ascertaining whether seeds are capable of germinating, I have seen gardeners throw them into water; discard those which swam on the surface as worthless, and sow only those which sunk. They judged by the weight of the seed, I suppose, whether it contained a sufficient quantity of carbon to have preserved the vital principle.

Mrs. B. Or, rather, they know by experience that heavy seeds are the most likely to germinate. Immersing seeds in water has also the advantage of preparing them for germination, by supplying them with the moisture of which they stand so much in need.

Emily. And it is, I suppose, the oxygen of the atmosphere which performs the office of relieving them from the excess of that element with which they are encumbered?

Mrs. B. Yes; it is therefore necessary that the soil should lie loosely and lightly over the seed, in order that the air should have access to it. The oxygen of the atmosphere then combines with the carbon of the seed, and carries it off in the form of carbonic acid gas. Seeds will germinate in contact with air which contains from one eighth to one third of oxygen: if the proportion be less, it will be insufficient to perform the function required; if more, the excitement will be too great, and the seed will perish from exhaustion.

Emily. The proportion of one fifth of oxygen, which the atmosphere contains, is, then, just the desirable medium. And heat, I conclude, is also essential to germination?

1327.—How long have some seeds been preserved, and by what means? 1328.—What would be the consequence if seeds were destitute of carbon? 1329.—What effects on seeds are produced by immersing them in water? 1330.—Why should the soil in which seeds are sown lie loosely? 1331 —What portion of oxygen in the air is needed to make seeds germinate?

Mrs. B. To a certain degree: seeds cannot germinate during a frost, for the water must be in a liquid state: about ten degrees of Reaumur, or fifty-five of Fahrenheit, is the temperature most favorable to the germination of plants in these climates. It is, moreover, requisite that the soil should be sufficiently permeable for the slender plumula, and the tender roots, when first shooting from the seed, to penetrate it; and, on the other hand, it must be sufficiently compact to support the roots and stem when full grown. The looser the soil is, the deeper the seed should be sown, in order to afford more support.

Emily. And in very loose soils the air has freer access, so that there is no danger of depriving the seed of oxygen by sowing it deep. Large seeds, I suppose, require to be sown deeper than small ones?

Mrs. B. Yes; but the largest should not be buried more than six inches in the ground, in order that the air may have access to them. Small seeds require to be merely covered with earth, in order to prevent the wind from scatering them, and to shelter them, in some measure, from the light.

Caroline. Is light, then, injurious to germination?

Mrs. B. The function of light, you may recollect, is to subtract oxygen from the plant, and occasion a deposition of carbon. Now, in germination, it is just the reverse which is to be effected.

When the seed, by absorption, has accumulated a sufficient quantity of moisture, it swells, bursts, the radicle shoots downwards, and the plumula rises in the opposite direction: the one becomes a root, the other a stem; and the almond of the seed is transformed into cotyledons. If any of these parts are destroyed, the plant is no doubt injured, but nature will restore them by fresh shoots. The neck, or vital spot which forms the junction between the stem and the root, being the only part, the destruction of which proves fatal to the plant.

Emily. Is it known why the stem always rises, and the root descends.

1332.—What degree of heat is needed for germination? 1333.—What should be the consistency of the soil that the seeds germinate well? 1334.—How deep should seeds be buried? 1335.—What is the function of light? 1336.—What takes place when the seed has acquired a sufficient degree of moisture? 1337.—What part must be destroyed to prove fatal to the plant?

Mrs. B. The roots, you must recollect, grow only at their extremities; and these, being at first of so soft a texture as to be almost liquid, naturally follow the direction of gravity and descend, unless they encounter some obstacle, such as a stone or clod of earth, so compact that they cannot penetrate it; in which case they grow out laterally, in order to avoid what they cannot overcome.

Mr. Knight performed a very curious experiment, with the view of ascertaining whether it was gravity which made the roots of a plant grow downwards. He sowed seeds in moss disposed in cavities, arranged on the circumference of a water-wheel. The cavities were open on both sides, so that the root and the stem were free to germinate at either. The wheel was then made to revolve one hundred and sixty times in a minute. The roots invariably struck in the direction diverging from the centre, like the spokes of a wheel: whence Mr. Knight was led to conclude, that, in this artificial process, the centrifugal force had replaced that of gravity.

Emily. That was a most ingenious contrivance. But the stem, on the contrary, grows upwards, and throughout its length.

Mrs. B. Let us suppose that it were free to grow in any direction. Since it shoots from the upper surface of the neck, it cannot grow downwards: it must, therefore, either rise vertically, or shoot out side-ways. In the latter case, it will be gradually brought to a vertical direction by the same cause which makes branches tend to grow upright; that is to say, the fluids which circulate in the stem having naturally a tendency downwards, some portion, however small, will exude from the upper to the under side of the lateral stem; so that the lower, being more amply supplied with juices, will vegetate with more vigor, and grow larger. The diminutive upper side will act like the cord of a bow, and make the stem approximate towards a vertical direction; and this cause, continuing to act on the stem so long as it is not upright, will ultimately render it erect.

1338.—Why do roots grow downward? 1339.—What experiment on the subject was made by Mr. Knight? 1340.—With what result? 1341.—In what two directions must the stem necessarily grow? 1342.—If it commence growing laterally how may it be turned upward?

Let us now consider more particularly how seed should be sown both in the fields and in gardens. In the former, the husbandman must prepare the land by ploughing, in order to render it as light as possible: the more it is pulverised, the more favorable it will be to germination. Choice must then be made of the finest grain.

Caroline. Is it not considered as advantageous to change the grain, and not sow that which grew in the same soil the preceding year?

Mrs. B. It is proper, we have observed, to vary the nature of the crop; but when, in the course of cropping, grain is to be re-sown, I believe that it is perfectly immaterial whether the seed sown was grown on the same land or elsewhere.

The seasons for sowing are in spring and in autumn. It is advisable to be done early in either season, especially in the latter, in order that germination should take place before the frost sets in. In the spring the period must be regulated by the nature of the season and the climate. The seed may either be sown by the hand or by a drill: M. De Candolle prefers the latter, as being more exact and regular in its operation. Care must be taken not to sow too thickly. When more seed is thrown into the earth than it can nourish, part of it will perish. But this is not the only loss; for, before it perishes, it will have consumed a portion of the nourishment which otherwise would have gone to the support of the surviving crop, and which, in consequence of this subtraction, cannot attain that vigor and perfection which is natural to it when well supplied with food.

Emily. This is very similar to the evil effects of the excess of population, which you explained to us in your Lessons on Political Economy, when poor weakly children perish, after having languished a few years, and consumed the food which would have fallen to the share of the rest of the community, if these supernumerary children had not been born.

Mrs. B. The analogy holds perfectly good.

1343.—How should seed be sown in fields and in gardens? 1344.—What is said of sowing seed on the same ground, where it grew the preceding year? 1345.—At what season should seed be sown? 1346.—How may it be sown? 1347.—If too much seed be sown, what will be the consequence? 1348.—What comparison does Emily make between this and a subject of political economy?

Lucerne has been transplanted to the distance of six inches from each other: and the plants growing larger, in consequence of their roots having a wider range for food, others have been transplanted to the distance of a foot; and others, again, as far as two feet asunder; and it was constantly found that the plants grew and flourished, in proportion as the distance between them increased.

Grains of wheat, sown very thin, have yielded from twenty to a hundred ears of corn.

Emily. There must, however, be a limit to this economy of seed.

Mrs. B. No doubt: land is not to be had at pleasure; but so long as the same extent of soil may be made to yield a better harvest, by sowing a less quantity of seed, it is no doubt highly advantageous.

The only exception to this rule is when you aim at producing long and slender stems. This is the case with hemp and flax. Comparative little value is set upon the seed: the stems, for making linen, are the essential produce. Those seeds must therefore be sown very thick, in order that the stems may grow long and upright, and no space be allowed them to branch out.

The Italian corn, with the straw of which hats are made, is sown very thick, with the same intention, and cultivated on a barren rocky soil, in order that a deficiency of nourishment may give the straw that morbid delicacy and slender form which render the Leghorn hats so fine.

Let us now turn our attention to garden culture. When seeds are sown from foreign parts, you may form some judgment of the degree of temperature and nature of the soil which they require, by the latitude and elevation of the spot whence they came. Seeds from tropical climates should generally be sown in hotbeds, having stone or wooden frames: the latter, being a worse conductor of heat, preserve plants from the cold better than the former. Experience teaches us that hotbeds are preferable to hothouses, both for the germination of the seed, and the growth of very young plants; and small hothouses are preferable to large ones (though of an equal temperature,)

1349.—What is said of the transplanting of Lucerne? 1350.—How should hemp and flax be sown, and why? 1351.—What is said of the culture of Italian corn? 1352.—And of garden seeds sown from foreign parts? 1353.—What does experience teach us in relation to hotbeds and hothouses?

so long as the plants have sufficient room to grow. Of course, they must not be cramped and stinted for space; for large plants require extensive accommodation: but the reason why a confined space is advantageous to small plants has not hitherto been ascertained. The heat generated by the fermentation of manure, is also more favorable to germination than the heat of a stove.

Caroline. That, I think, is easily accounted for. The heat of a stove is of a drying nature, whilst that of the fermentation of manure is always accompanied by moisture, which will accelerate the swelling of the seed and bursting of its coats. And why should not this be the reason, that a hotbed is preferable to a hothouse, for the purpose of raising plants from the seed? For the one is heated by fermentation, the other by a stove.

Mrs. B. The pots in which they are sown are frequently placed in beds of manure in a hothouse. Besides, the same argument holds good with regard to greenhouses: the smaller the house, the better it is calculated for the culture of small plants. It has been suggested, that small plants being always placed in the front and lowest rows of the greenhouse, and hot air having a tendency to rise, they occupy the coldest strata of air.

In the preparation of hotbeds, the manure of horses is preferable to that of cows, as it more readily decomposes, and enters into combination with vegetables. That of pigeons possesses this quality in such a remarkable degree, that it is dangerous to germination, by precipitating it too much.

Caroline. The seeds, however, are, I believe, never sown in manure itself, but in pots of earth which are sunk in it; the plant, therefore, benefits only by the heat and the evaporable particles.

Mrs. B. That is true. Little or no manure should be mixed with the earth contained in the pots, in which germination takes place; for the seed, at that period, far from being in want of food, requires to get rid of a surplus of carbon.

1354.—What comparison is made between the heat of a stove and that generated by fermentation? 1355.—What reason does Caroline give for this comparison? 1356.—What has been suggested as to the placing of small plants in greenhouses? 1357.—What comparison is made between different kinds of animal manure? 1358.—What is said of mixing manure with the earth in which the germination of seeds is to take place?

Emily. But when the germination of the seed is completed, and the roots shoot out in search of food, some provision should be made for them.

Mrs. B. If the earth contained in the pots consists of rich garden-mould, it will afford a sufficiency. When land is manured for grain, the seed derives no advantage from it: the embryo plant is nourished by the albumen; and it is not till the roots have acquired some consistence and vigor that they begin to supply the plant with food from the soil.

You must observe that it is necessary to cover the hole, which is made at the bottom of all garden-pots, with a small piece of tile; and it is proper, also, to place a second piece, of larger dimensions, over the first, in order effectually to prevent the too rapid filtration of water. Care must be taken to keep the earth light and loose over seeds which are germinating; for if the soil be calcareous in drying, after being watered, a crust frequently forms on the surface, through which the slender stem cannot penetrate, and the young plant is thus literally buried alive. The surface of the mould must, therefore, be kept scratched or raked, to prevent this crust from forming; or to pulverise it, if the evil has already taken place.

Shallow wooden boxes are frequently used, instead of pots, for the purpose of sowing seeds: they have the advantage of affording them more space.

When plants have so far increased in size as to require transplantation, they should not be pulled up by the roots, but the whole clod of earth be carefully shaken out of the pot at once, and then gently divided into parts, so as to run no risk of wounding the fibrous extremities of the roots in separating them from the earth which surrounds them.

Emily. I have observed that, in transplanting them, the gardener uses a pointed instrument to make a hole in the ground, and afford room for the roots of the young plant.

Mrs. B. This is exactly the reverse of ploughing: it makes an opening to receive the young plant, no doubt,

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1359.—Why is not manure needed for the embryo plant? 1360.—Why should the opening at the bottom of flower pots be covered 1361.—Why should the earth be kept light and loose over seeds which are germinating? 1362.—What advantage have shallow wooden boxes over pots? 1363.—When plants are to be transplanted how should it be done?

but it is at the expense of the contiguous soil, which is rendered proportionally more compact. It is true that the young vegetable, at the period of transplantation, has acquired some vigor; and a light soil is not so essential to it as during germination. It is preferable, however, to transplant in furrows, when the earth is turned up with a spade or a hoe, and the roots afterwards covered by raking the earth over them.

But we are deviating from our subject. Now that we have fairly traced the seed through the process of germination, we should conclude our conversation, and reserve what remarks I have to make on planting to some future day.

CONVERSATION XXI.

ON THE CLASSIFICATION OF PLANTS.

Emily. You have often talked to us of plants belonging to different families, my dear Mrs. B., but you have never explained the exact meaning of the word family in the vegetable kingdom; and I wish you would also teach us, how to find out, to which family a plant belongs.

Mrs. B. Your question is much more complicated than you are aware of; and I know not how to give you a satisfactory answer without explaining the whole theory of classification, which will be long, and sometimes, perhaps, you may find it tedious.

Emily. I have no fear of undertaking it; for I am conscious it is necessary, and that, without such information, it would be difficult to remember many things that you have taught us.

Mrs. B. You are quite right: the number of natural beings is so immense, that without some mode of classification it would be impossible to form a correct idea of them. Would you believe that there are no less than sixty thousand species of plants already known, and that this number is increasing every day?

Caroline. Oh, Mrs. B., what a host!

1364.—What is the best mode of transplanting, and why? **1365.**—What does Mrs. B. say of the difficulty of dividing plants into families? **1366.**—Why is classification necessary? **1367.**—How many species of plants are already known?

Mrs. B. You have named it very justly. Well, then, to carry on your comparison of a host, do you conceive that any general, in reviewing sixty-thousand soldiers, would be capable of recollecting every individual?

Caroline. Certainly not; but as each regiment has its uniform, and each company its number, he could easily discover to which any soldier belonged.

Mrs. B. This is exactly the object a botanist has in view in classification. He endeavors to find out to which regiment and to which company each individual plant belongs; but this is much more difficult than with an army, where the general has himself chosen the uniforms, and arranged the companies so as to make the distinctions most conspicuous. Nature has also, it is true, her distinguishing characters, but they are often placed in organs which are least exposed to view; and botanists do not always agree on the characteristic features of plants.

Caroline. Well; but tell us at least on what points all botanists do agree?

Mrs. B. Willingly. You see yonder in the garden a bed of carrots: every individual plant of which belongs to the same species.

Caroline. Of course; for I know that the gardener collected the seed sown in that bed from one individual plant last year, so that the carrots must all be descended from the same parent.

Mrs. B. Now, then, if you extend your idea to all the carrots in the world, which do not differ from the carrots in this bed, more than these differ from each other, you will understand that they may originally have been derived from the same plant.

Emily. Certainly; and that is what we have said constituted a species.

Mrs. B. Well, then, if this idea is clear to you, let us proceed a step further, and, considering each species as a unity, compare them with one another. Can you recollect any instance of different species bearing a striking resemblance to each other?

1368.—What comparison is made between this subject and an army of soldiers. 1369.—What is said of the distinguishing characters of plants? 1370.—How does Mrs. B. explain what is meant by a family? 1371. —This being done, what does she next propose doing?

Caroline. Oh, yes; there is the white rose, the yellow rose, the China rose, and many others, which are very much alike; and yet the gardener assures me that the seed of the one will never produce the other.

Emily. Red clover, white clover, and yellow clover, bear also a similar resemblance to each other, though they are all of different species.

Mrs. B. Your examples are well chosen; for the most ignorant person could understand them. Species bearing this analogy are classed together under the name of *Genera.* The resemblance of the different species composing some of the genera is so striking, that their affinity cannot be mistaken; while in others it is less marked, and requires some study to be recognised.

Caroline. Like different children of the same family, some of whom are so much alike that you see at once they are brothers and sisters; while, in others, the relationship cannot be traced in their features.

Mrs. B. The word *genus* is a Latin word, signifying family: your comparison, therefore, cannot but be accurate; and, by following it up, I think you may acquire an idea of the whole system of nomenclature. You may easily conceive, that if there were a separate name for each of the sixty thousand species of plants, no memory could retain them; nor could these names point out the resemblances or differences which exist between the several species.

Emily. Of course; just as if every individual of a country had a different surname: it would be impossible to know, among which of them, any relationship existed.

Mrs. B. I see that you have nearly made out the simple art of nomenclature. Each genus has a substantive name; as rose, carrot, clover: to which is added the epithet of white, black, large, small, to designate each species; so that, instead of sixty thousand names, five thousand only are sufficient: to which are added a certain number of epithets in common use, and understood by every one.

Emily. There is, then, really a great analogy between the nomenclature of plants and that of mankind, for the

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1372.—What instances are mentioned of different species bearing a striking resemblance to each other? **1373.**—What are *genera* and what is said of them? **1374.**—What is said of the word genus; and how is the importance of its use in Botany illustrated? **1375.**—What further illustration of its advantage is given; and how much is the number of names in Botany diminished?

names of the genera correspond with our family names, and those of the species with our Christian names.

Mrs. B. Very true. It is to the celebrated Linnæus that we are indebted for this simple and clear mode of nomenclature; and it is one of the circumstances which has contributed most to facilitate the study of botany. Since, then, the basis of nomenclature rests on the idea of genera, you may judge how important it is that this idea should be clearly understood, and that plants not possessing the requisite analogy should not be placed in the same genus.

Emily. It would be easy to ascertain this analogy with regard to the species, by sowing their seeds: but I know not what test there is to verify the genus of a plant?

Mrs. B. No wonder you should be at a loss, for it is a question which has embarrassed the most celebrated botanists. There is but one means of forming a clear idea of genera: it is by placing its distinguishing characters in those organs of the plants, which, in the common course of Nature, are least liable to variation. Now, it has been observed, that stems and leaves more frequently vary in their structure than flowers and fruit: botanists have, therefore, agreed to place the characters of the genera in the organs of fructification.

Emily. But are not flowers of the same species sometimes blue, and sometimes white; sometimes large, and at others, small? How, then, can you establish the character of the genera, on circumstances which cannot even serve to distinguish the species?

Mrs. B. The difference or resemblance of organs, must not all be considered as of equal importance, in deciding the genus of the plant. All such as relate to color, flavor, smell, consistence, and the absolute size of the organs, must, in classification, be set aside; and those only which are connected with the symmetry of the flower or fruit, the number of plants, their shape, and relative size, are to be attended to.

1376.—What analogy does Emily say there is between the names of our families and the names of plants? 1377.—To whom are we indebted for this mode of nomenclature? 1378.—How can the genus of a plant be determined? 1379.—What has been observed in relation to this subject? 1380.—In what are placed by Botanists the characters of the genera? 1381.—In the classification of plants what circumstances must be set aside, and what ones attended to?

Caroline. Why do you consider the relative size of organs of more importance than their absolute size?

Emily. That appears to me quite clear. If a plant grows in a rich soil, all its parts will be larger than a similar plant growing in a meagre soil; yet the plants will be of the same nature. But if the stamens of a plant be twice as long as its petals, it will certainly be of a different nature from a plant of which the stamens are shorter than the petals; and, were the two plants well or ill fed, their proportion or relative size would not be altered.

Caroline. You say, Mrs. B., that the number of organs of a plant is admitted as one of the characters of genera; but I think, I remember having seen, on the same syringa shrub, flowers, some of which had four, and others five petals.

Mrs. B. Your observation is correct; and, in order to obviate this difficulty, you must be guided by the same rule, in regard to number, which Emily has just pointed out with regard to size. Thus, for example, the pink has twice as many stamens as petals: this character never varies, unless in some peculiar cases of monstrosity which derange the whole economy of the plant.

With regard to the absolute number of organs, that is to say, whether a plant has four or five petals, eight or ten stamens, is a circumstance attended with much more uncertainty; it may, however, be used as a character in classification, provided it be done with caution, and in cases only, in which experience has shown, that the variations are inconsiderable. Botanists know, for instance, that the greater the number of organs, the more liable that number is to vary. This is a law which prevails throughout all Nature.

Emily. It is evident that the number of our fingers varies less than that of our teeth, and the latter less than that of our hair.

Mrs. B. These general rules will, I hope, make you understand how botanists have been enabled, gradually to draw a more accurate line of demarcation in circum-

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1382.—What appears quite clear to Emily? 1383.—What does Caroline mention of the syringa shrub? 1384.—In order to obviate this difficulty, by what must one be guided; and what example is given? 1385.—What is said of the absolute number of organs in plants? 1386.—What law relating to this subject is said to prevail throughout all nature? 1387.—How have Botanists been benefited by the general rules above given?

scribing the genera of plants, and determining their characters. This constitutes one of the most essential branches of botany; for it is certain, that the better the structure of plants is known, the more easily new plants are discovered, because we are enabled to ascertain their characters, and, consequently, to class them with greater precision; and thus the art is gradually brought to some degree of perfection.

Emily. But since the nomenclature is founded upon genera, if you change the genera you must change also the names of plants, which is very perplexing for beginners.

Mrs. B. That is true; but it would be a source of still greater perplexity to allow a plant to remain in a genus, in which, through ignorance, it had been erroneously placed, and of which it had not the characters, for you would never be able to recognise it. Let us suppose, for instance, that the pear-tree had been placed in a genus, the distinguishing character of which, is to have six petals: as it has only five, you would never think of searching for it in a genus of six petals. Would you, then, disapprove of its being transferred to the genus whose character is to have five petals?

Emily. No; certainly; but such errors seem to me to be impossible.

Mrs. B. Not so much so as you imagine, owing to the number of the organs frequently differing in the same plants, like the petals of your syringa. Besides, foreign plants are often described in a hurried manner by incompetent botanists, and are sometimes brought to Europe in such an imperfect state of preservation as to afford very bad specimens. You see, therefore, that in this case, as well as in many others, truth must be preferred to simple convenience.

Caroline. But, my dear Mrs. B., you have not yet said one word of the families of plants, which you had promised to explain to us.

Mrs. B. A little patience, my dear. I cannot tell you every thing at once; and I like to begin by the beginning. I have explained to you how all individual plants, resembling each other, form a species; and how, by fol-

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1388.—How is it said that the classification of plants can be made with the greater precision? 1389.—What does Mrs. B. think would increase the perplexity, which Emily has suggested? 1390.—How is this illustrated by the supposition of the pear tree? 1391.—Of the difficulty in classifying foreign plants what is said?

lowing up the same idea, and uniting in your mind all the species whose flowers and fruits are nearly similar, you form a genus. When you have accomplished this, proceed a step further: consider the genus as a unity; and we will then endeavor to make out how the five thousand genera of the vegetable kingdom can be so arranged as to be most easily recognised. But first tell me what is your particular aim in studying botany?

Caroline. I wish to be able to find out the name of any plant I may chance to meet with.

Emily. I confess, for my part, that I am not very anxious about the name; but I should like to understand the structure of any plant I see, and how far it coincides with or differs from other plants.

Mrs. B. You have each answered as I expected. Caroline, who is the youngest, and the most volatile, is satisfied with inquiring after names. Emily, who is older, and more considerate, seeks after things. Well, my dears, the learned world have done like you. In the infancy of botany, they sought after names: when further advanced, they aimed at learning the essence of things. I shall follow their steps, and first explain to Caroline, by mere nomenclature, how to find out the name of a plant; and then teach Emily, what has been called, the natural method. But I think you must be tired to-day: we will, therefore, defer it till our next interview. In the mean time, reflect upon the subject; and let me know, when we meet, which you think may be the best means of attaining the object you each have in view

CONVERSATION XXII.

ON ARTIFICIAL SYSTEMS OF CLASSFICATION OF PLANTS.

Mrs. B. I have promised to explain to you to-day, Caroline, how to discover the name of a plant. But why should you not inquire of some botanist the names of the

1392.—What explanations of individual plants, and the manner in which a genus is formed, are already given? 1393.—What does Mrs. B. now propose doing? 1394.—How does she compare the progress of Botanical science with the ages of Caroline and Emily? 1395.—What plan of explaining the science is she further to pursue?

plants you may wish to know, and then fix them by rote in your memory?

Caroline. Oh, Mrs. B., you think me still more childish than I really am. In the first place, is it probable that I should always meet with a person capable of telling me the name of a plant? And, then, I should be liable to be imposed upon and misinformed. No; what I desire is to be enabled to find out the names of plants myself—with the assistance of books, I mean.

Mrs. B. It would be necessary for this purpose to have a dictionary arranged the very reverse of those commonly used. Instead of giving the word, and then the definition, as dictionaries usually do, you must begin by learning the characters of plants, and then come to the name.

Caroline. But a dictionary of this description would be but of little use to me; for, as I am completely ignorant of the characters of most plants, I should not know where to seek for them in the dictionary. Indeed, my principal reason for wishing to know their names is to be able afterwards to learn their history, and become acquainted with their uses and properties.

Mrs. B. I see that Caroline is coming round to your opinion, Emily; she proceeds from names to things. This shows me that you have reflected upon the subject, since our last interview. Various modes have been resorted to, with a view of composing the peculiar species of dictionary to which I have alluded; and, in order to give you some idea of them, tell me, have you ever played at a game called *Four-and-twenty Questions*?

Caroline. Oh, yes; I am quite an adept at it. One of the party thinks of a word or a thing, and the others try to discover it, in a series of twenty-four questions.

Mrs. B. In this game, the art consists in so skilfully pointing the questions, that each reply shall contract the field of inquiry, till it is at length brought within so small a compass, that the object thought of is attained.

Emily. It is like the Indian mode of entrapping elephants. They are surrounded by horsemen, who at first

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1396.—What does Caroline desire to learn? 1397.—What kind of a dictionary would she need? 1398.—What makes Mrs. B. think Caroline has been reflecting on the subject? 1399.—To what game does she refer with a view to explain the mode of learning the names of plants? 1400.—How does she describe this game?

enclose a large space of ground, but, gradually narrowing the circle, drive them gently towards the centre; where they have no resource but to run into the trap, which is there open to them.

Mrs. B. Well, botanical nomenclature is very much the same thing. Indeed, the analytical method—the simplest hitherto used—is exactly similar to the game of Four-and-twenty Questions. It was first introduced by M. De Lamarck, and forms the basis of a work he published, with M. De Candolle, called the *Flore Francoise.*

Here is a plant in blossom in this flower-pot: I know that it grows wild in the south of France. I shall ask you a few questions relative to it, according to the method followed in the *Flore Francoise*, and you will see that you will soon discover the name of the plant yourself.

Caroline. Oh, that will be very amusing.

Mrs. B. First, then, tell me whether the flowers are visible to the naked eye, or whether they require to be seen through a microscope?

Caroline. The plant is quite covered with them, and they are perfectly visible; for you may see them from some distance.

Mrs. B. Are the flowers united by an involucrum or not?

Caroline. No; they have no involucrum.

Mrs. B. Have the flowers both pistils and stamens, or only one of these organs?

Caroline. They have both.

Mrs B. Have the flowers both a corolla and a calyx?

Caroline. Yes; they have both.

Mrs. B. Is the corolla of one entire piece, or composed of several parts?

Caroline. It consists of several parts.

Mrs. B. In this case, I must refer to No. 211. of the *Flore Francoise;* and pray tell me, does the ovary adhere to the calyx or not?

Caroline. It adheres to the calyx, and is consequently situated below the petals.

Mrs. B. Are there several ovaries?

Caroline. No; only one.

1401.—To what does Emily say it is like? 1402.—Who introduced the method of studying Botany here named? 1403.—How does Mrs. B. propose to teach her pupils the manner of ascertaining the name of some particular flower?

Mrs. B. Is the flower regular or irregular?

Caroline. Regular.

Mrs. B. Are there more or less than twenty stamens?

Caroline. There are, certainly, more than ten; and I should think about twenty.

Mrs. B. Is the calyx divided into more than two lobes?

Caroline. Yes; into five.

Mrs. B. Are the leaves opposite or alternate?

Caroline. They are opposite, and placed very regularly on the stem.

Mrs. B. Is your plant herbaceous, or is it a shrub?

Caroline. A shrub.

Mrs. B. Is the fruit dry or fleshy?

Caroline. Let me see if I can find any: there is very little fruit; but it appears to me fleshy.

Mrs. B. Is that part of the calyx which crowns the fruit membranaceous or coriaceous?

Caroline. It is membranaceous.

Mrs. B. Well, then, your plant must be a myrtle. Were there several species of myrtle growing in France, by continuing a similar series of questions, I should soon discover the species; but as there is only one (which is the common mrytle,) I am already fully answered.

Caroline. What a simple and ingenious method! You would easily have won the game of Four-and-twenty Questions; for you have asked only thirteen. This mode of analysis must, I suppose, be in very general use?

Mrs. B. It has been much used in France, but very little in England; nor do I know any English work on botany arranged according to this method.

Caroline. I am surprised at that. Is there any thing to be objected to it?

Mrs. B. It has been thought long and tedious; and, to one no longer a novice in botany, it is tiresome to have always to recommence and follow up the same routine of questions; besides, the slightest inattention, or the least mistake in the printed numbers, is sufficient to put you quite out. Then, after all, when you have succeeded in

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1404.—If there had been several species of myrtle growing in France, what might have been learnt in the same way? 1405.—What is said of the use of this system in France and England? 1406.—What is the first objection made to this system?

discovering the name of the plant, it is not very easy to remember the characters which enabled you to find it out. Notwithstanding these objections, which certainly have their weight, I cannot but think this method the best for beginners.

Caroline. Still, if it is not used in England, it would not be of much use to us. Pray, what mode of nomenclature is adopted by English botanists?

Mrs. B. That which we owe to Linnæus, which I have here, and will show you.

Emily. Pray do; for the name of Linnæus is so celebrated, that any method invented by him cannot but be interesting.

Mrs. B. You are right. A method derived from a man so eminent in science, and which has been adopted by so many other scientific men, well deserves our attention. Here is a table of the different classes into which Linnæus divided the vegetable kingdom.*

Caroline. It appears very complicated!

Mrs. B. It is less so than you imagine. This system of Linnæus forms precisely an analytical table. Return to your myrtle, and let us follow it.—Stamens visible to the naked eye, in the same flower as the pistils, but not united to them; all of the same size; about twenty in number; growing from the calyx: the myrtle belongs to the class Icosandria of Linnæus.

Caroline. And then what follows?

Mrs. B. These classes are divided into orders, which depend principally on the number of styles.

Caroline. The myrtle has only one style.

Mrs. B. Therefore it belongs to the order Icosandria Monogynia. Here is an edition of Linnæus, published by Willdenow. You see that the above order contains

* See, at the end of the Conversation, page 264.

1407.—When the name of the plant is discovered what other difficulty occurs? 1408.—On the whole what is the opinion of Mrs. B. of this system? 1409.—What mode of nomenclature is adopted by Botanists in England? 1410.—On what account is his system entitled to notice? 1411.—How does the system of Linnæus apply to the myrtle? 1412.—On what does the order depend into which these classes are divided? 1413.—What is seen respecting the myrtle in the edition of Linnæus published by Willdenow?

twenty-two genera: you must therefore examine the characters of each genus, and you will soon find out those which correspond with the myrtle.

Emily. This method, certainly, must be much more complicated than the other.

Mrs. B. It may appear so to a beginner; but you would soon become used to it: and I assure you that it is a very convenient mode of discovering the names of plants; at least, of those which do not belong to a class containing a very great number of genera; such, for instance, as those of ***Pentandria*** and ***Syngenesia***, which contain from four to five hundred each. But, even in these cases, practice and habit soon render familiar a system which at first sight appears perplexing and difficult.

Emily. How often have I made that observation! When I first began learning the piano-forte, I shall never forget the difficulty I had to distinguish the different notes; whilst now I play without ever thinking of them. But, Mrs. B., the system of Linnæus rests almost entirely on the number of the different organs of plants; and we have observed more than once, that number is a character which can be little relied on in botany. Yesterday we mentioned the irregular number of petals of the Syringa; and this morning I observed a plant of rue which bore in the same cluster flowers, some of which had eight, and others ten stamens. Does it belong to the eighth or the tenth class? I am sure I deserve to know, were it only to make up for the disagreeable smell I had to encounter in examining it.

Mrs. B. In cases of this sort, botanists have agreed to class the plant according to the first flower which blows in the cluster; and, following this rule, the rue belongs to the tenth class. But what is still more embarrassing is, that the number of stamens often vary in an irregular manner. Thus you may meet with tulips, and several other plants, bearing indifferently five, six, seven, or eight stamens. In this case you must class them according to the number most usually found.

1414.—How does this system appear to the young student in Botany? 1415.—What will practice and habit, in its use do? 1416.—What does Emily say of a plant of rue, and what question does she propose to Mrs. B? 1417.—How is it answered? 1418.—What is said of tulips and some other plants explanatory of this subject?

Several other sources of error occur in the system of Linnæus. For instance, there are many plants in which the inequality of the stamens, and their adherence, is so difficult to distinguish, that it is not easy to know to what class they should be referred. There are also *Diœcious* or *Monœcious* plants, which are become so by mere accident; and which you would seek for in vain under the head *Diœcia* or *Monœcia*.

The class *Polygamia* is also one of those which can scarcely be made out by a beginner. Notwithstanding the imperfections of the Linnæan system, it is one of the most convenient: and, were it less so, it would be necessary, in order to make any proficiency in botany, to be well acquainted with it, as it is that which is most generally used in botanical works.

Emily. But, in small flowers, does not the extreme minuteness of the organ which it is neccessary to investigate, render the system of Linnæus liable to error?

Mrs. B. True; this is one of the sources of error which even the genius of Linnæus could not overcome.

Emily. When two plants have each an organ perfectly similar, is it a necessary consequence that they should resemble each other in other respects?

Mrs. B. Sometimes, but not always. Thus, in this system of Linnæus, the class Tetradynamia contains plants all having a certain natural resemblance; the same may be said of the class Syngenesia; but in the other classes they frequently differ considerably.

Emily. This is not very logical, I think!

Mrs. B. It is true that it would not be so, had Linnæus meant that his system should point out the real differences of plants. But his intention was merely that it should answer the purpose of a dictionary, by means of which it would be easy to discover the names of plants; and, in this point of view, it may fairly be affirmed, that the greater the number of points of difference existing between plants, belonging to the same class, the easier it is to discover the name of each.

1419.—What other sources of error are found in the system of Linnæus? 1420.—On the whole, how does Mrs. B. consider his system? 1421.—What difficulty with small flowers arises from it? 1422.—What is said of the class Tetradynamia, and of the class Syngenesia? 1423.—What was the intention of Linnæus to the purpose of his system?

The followers of Linnæus have unfortunately not always well understood his intention of thus supplying botanists with a mere nomenclature, or, as it has been called, an *Artificial System;* and the habit of studying the pistils and stamens has made them attach too great importance to these organs of fructification, while they have neglected the fruit and the seed. They have also, in general paid too much attention to the number of the organs, and not sufficiently considered their relation to each other; so that, if they have rendered it an easy thing to discover the name of a plant, they have not advanced the science of botany so much as they would have done had they directed their researches more to the general properties of plants.

Emily. The system of Linnæus might, I think, be compared to a dictionary, which, though you learnt all the words it contained by heart, you would still be ignorant of the language, unless you added to it a knowledge of the grammar which teaches the value of the relative terms.

Mrs. B. Well; that arrangement, which is called the *Natural System,* teaches you the grammar. But, in reply to your observation, I might retort that a grammar alone is not sufficient to make you acquainted with a language—a dictionary is also necessary, in order to look out for the words; you must not therefore undervalue botanical dictionaries, which facilitate the study of nomenclature: yet always bear in mind that they teach only the names of plants; and that, if you wish at the same time to acquire a general knowledge of their structure, you must study the *natural system.*

Emily. That is what I am most anxious to do: pray give us some general idea of it.

Mrs. B. With pleasure; but not to-day: we shall examine it when next we meet. In the mean time reflect upon the subject, and endeavor, of your own accord, to discover some mode of classing plants which would most easily show their true analogy.

Caroline. I will think of it; but it appears to me a very difficult task.

1424.—In what have the followers of Linnæus sometimes been unfortunate? 1425.—Why have they failed to advance the science of Botany as much as they might? 1426.—To what does Emily say the system might be compared? 1427.—What system teaches the Grammar of Botany? 1428.—What comparison does Mrs. B. make between the system of the Linnæus and the Natural system?

- Plants with stamens and pistils.
  - Visible to the naked eye.
    - United in the same flower.
      - Not adherent together.
        - Stamens equal to each other.
          - Less than 20 Stamens.
            - 1 - - - - 1 Monandria.
            - 2 - - - - 2 Diandria.
            - 3 - - - - 3 Triandria.
            - 4 - - - - 4 Tetandria.
            - 5 - - - - 5 Pentandria.
            - 6 - - - - 6 Hexandria.
            - 7 - - - - 7 Heptandria
            - 8 - - - - 8 Octandria.
            - 9 - - - - 9 Enneandria.
            - 10 - - - - 10 Decandria.
            - from 11 to 19 - - - 11 Dodecandria
          - 20 stamens at most.
            - growing on the calix 12 Icosandria.
            - not growing on the calyx 13 Polyandria.
      - 4 stamens, 2 of which are long - - 14 Didynamia.
      - 6 stamens, 4 of which are short - - 15 Tetradynamia.
      - Adherent to each other.
        - Stamens not adherent to the pistil, but soldered together.
          - By the filaments.
            - All bound in a single bundle - - 16 Monadelphia.
            - In two ditto - - 17 Diadelphia.
            - In more than two do. 18 Polyadelphia.
          - By the anthers - - - - 19 Syngenesia.
        - Stamens glued to the pistil - 20 Gynandria.
    - In two different flowers
      - Flowers with stamens, and flowers with pistils on the same plant 21 Monœcia
      - Flowers with stamens, and flowers with pistils on two different plants 22 Diœcia.
      - Flowers with stamens and pistils, or having the one or the other organ on one, two or three individuals 23 Polygamia.
  - Invisible to the naked eye - - - - 24 Cryptogamia.

CONVERSATION XXIII.

ON THE NATURAL SYSTEM OF CLASSIFICATION.

Mrs. B. Well, my dear, have you been able to discover any mode of classing plants, according to the analogy they bear to one another?

Caroline. I have endeavored to class the plants in our garden according to this method. I began by comparing them altogether, and then divided them into groups, according as they more or less resembled each other.

Mrs. B. I should have no fault to find with your mode of proceeding, if the whole vegetable kingdom contained, like your garden, only a small number of plants. This mode was, in fact, the first emyloyed, and was called the *Methode de Tatonnement.* Even now it is occasionally employed by botanists, as a guide in their researches. But you will easily understand, that, independently of the impossibility of being put in practice, since the number of plants known has so much increased, it has also the great defect of depending merely upon opinion, and affording no certainty of the reality of the resemblance assigned to different plants. It is much the same as with likenesses of different persons: how often people vary in opinion in regard to such resemblances!

Caroline. So much so, that, while many people declare that I am the very picture of my father, others see no resemblance whatever between us.

Mrs. B. The same diversity of opinion would take place in natural history, had not botanists laid down certain precise rules for judging of the external characters of plants; and, Emily, have you no new mode of classification to suggest.

Emily. If I tell you the one that has occurred to me, I fear you will think me very presumptuous.

Mrs. B. By no means, my dear: on the contrary, nothing is more gratifying to me, than to see that you are capable of reflection, whatever may be the object.

1429.—What does she direct Emily to do? 1430.—How does Caroline attempt to class plants according to analogy? 1431.—What is this mode called? 1432.—Why is this hypothesis objectionable? 1433.—How is this objection illustrated from a reference to a picture?

Emily. We examined yesterday the system of classification founded upon a single organ: well, if I had to class the vegetable kingdom, and was well acquainted with the structure of plants, I should make as many different arrangements as there are different organs. The first, for instance, would be made after the roots, the next after the stems, the following after the leaves, another relating to their position, another according to the number of the organs, and so on. I should thus form, perhaps, a hundred different systems. Now, I suppose that the plants which were placed together in ninety-nine of these systems would bear the strongest possible resemblance to each other; in ninety-eight, a little less so: in a word, that the resemblance between plants could be ascertained by the number of systems common to each.

Mrs. B. Your idea is very ingenious, my dear Emily; and, though I do not agree with you in opinion, you may boast of having suggested the same theory as a very distinguished French botanist, M. Adamson. He called it, "Method of General Comparison," and bestowed much labor upon it; but, as he lived so long ago as the year **1760**, he was far from being acquainted with all the different characters of plants, which rendered his system very incomplete. Even in our time, though great progress has been made in botany, new characters and properties are frequently discovered in plants; consequently, a classification of this description would still be incomplete.

Emily. I own that objection did not occur to me, because I thought that the degree of precision in any mode of classification depended upon the state of the science at the time it was made.

Mrs. B. There is another objection, of still greater weight. According to your system, you count the number of organs that resemble each other in different plants, but you make no estimate of the relative importance of each; yet you must consider that all the organs are far from being of equal importance. Plants which resemble each other in a few of their principal organs, have more

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1434.—How does Emily propose to give plants a Natural classification? **1435.**—What does she suppose in relation to such classification, when made? **1436.**—What French chemist proposed the same theory? **1437.**—How would it be objectionable from the new characters and properties of plants with which we are becoming acquainted? **1438.**—What other objection of still greater weight is there?

real analogy than those which are similar in a great many minor points. You may easily conceive that plants whose seeds are alike, resemble each other infinitely more than those which shoot out thorns of the same nature. For the seed may be considered as the miniature of the plant, from the developement of which all the growth of it must arise; while the thorn is a mere accidental degeneration, which may or may not take place.

Emily. This objection is certainly of great weight, and I am afraid that I must abandon my system; but is it possible to appreciate the relative importance of the different organs?

Mrs. B. To a certain extent, at least. The method of classification, grounded on this principle, is called "Method of Subordination of Characters." It was first suggested by Bernard Jussieu.

Emily. How much I should like to read his work on this subject!

Mrs. B. He never published any thing: like Socrates, he taught in conversation. His nephew, M. Antione Laurent De Jussieu, who is still living, published, in 1789, the results of his uncle's theory. In 1823, M. De Candolle published a work, in which the principles of this mode of classification are fully developed: they are probably the same as those of M. De Jussieu, since his deductions from them are similar to those of his predecessor.

Caroline. Then M. De Candolle must be the Plato of this modern Socrates?

Mrs. B. Or even something more: for Plato, I believe, wrote only what Socrates had taught; but M. De Candolle brought to light those principles from which M. Bernard Jussieu had drawn his deductions.

Emily. It is a curious thing in science, for the founder of a new school not to publish his opinions. But, pray, what are these principles? They must, I think, be very difficult.

Mrs. B. We have agreed that all the organs of plants are not of equal importance: now there are three modes

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1439.—What may be conceived of plants whose seeds are alike? 1440.—What is this theory called and who first suggested it? 1441.—Who published the theory of Jussieu? 1442.—And who published a work in 1823 which involved the same principles of classification? 1443.—What comparison does Mrs. B. make between Plato and the younger Jussieu?

of ascertaining the degree of consequence of each. The first is its utility: this is the most general, and would be sufficient of itself, were we so perfectly acquainted with vegetable physiology, as to judge of the importance of an organ, by its degree of utility in the economy of a plant. Thus we may safely conclude, that an organ essential to the life of a plant, is of a higher order than one of which it can be deprived, without sustaining any material injury.

Emily. But are the functions of different organs not sufficiently known, to enable us to judge whether they are more or less essential to a plant?

Mrs. B. Not always; but in a doubtful case, there are two other rules by which you may be guided. Generally speaking, the greater the number of plants in which the same organ can be found, the greater is the degree of importance that ought to be attached to them. For instance, the calyx may be pronounced to be an organ of much greater consequence than the involucrum, because a much greater number of plants have a calyx than an involucrum.

Emily. I understand that perfectly.

Mrs. B. There is besides a third criterion. There are certain organs which exist, or which are wanting, in all the plants of the same family; and others that are only occasionally found in plants, otherwise very similar to each other. The first of these organs are naturally of much greater importance than the latter, as they appear to be indispensable to the system of organisation of these plants. Were you to ask me, for example, whether a stipula or a thorn were of greatest importance, I should not hesitate to say the stipula, for the reason I have just assigned.

Emily. When you judge of the importance of an organ by its degree of utility in the economy of a plant, how can you compare organs adapted to functions of a completely different nature? In the animal frame, it would be difficult to determine whether the lungs were a more useful organ than the stomach, the eye than the hand—does not the same difficulty occur in the vegetable structure?

1444.—How many ways are there of ascertaining the importance of the organs of plants? **1445.**—What is the first, and how is it explained? **1446.**—How does the number of plants in which any particular organ is found effect its utility? **1447.**—How is this illustrated by the calyx and volucrum? **1448.**—What is the third criterion? **1449.**—How is that illustrated by the stipula and thorn? **1450.**—What question does Emily ask, indicating the difficulty of ascertaining the utility of organs by comparison?

Mrs. B. Your observation is perfectly just; and, in fact, botanists can only, with any degree of certainty, compare such organs as are adapted to the same class of functions. For instance, you will readily admit that the brain is of higher rank than any single nerve, and the heart superior to any other blood-vessel: but if you inquired whether the heart or the brain were of greatest importance, it would be quite out of my power to answer you. If you will promise not to laugh at me, I will venture upon a very trivial comparison.

Caroline. Pray, let us hear it, Mrs. B.; I am so fond of comparisons—indeed, I often understand them better than arguments.

Mrs. B. You are, no doubt, aware that a captain is of higher rank in the army than a lieutenant, and a colonel than a captain; you know, also, that the governor of a province is of more elevated dignity than the mayor of a small town: but, pray, how would you answer, if I asked you whether a captain or a mayor ranked highest? You might say, in some particular cases, the one takes precedence of the other; but that would depend entirely upon arbitrary decision, and not on the nature of their functions, which will not admit of comparison. Now, if you apply this simile to vegetable physiology in which there are two great classes of functions; one of which belongs to the re-production, and the other to the nutrition, of plants; you will understand that those organs alone admit of comparison which belong to the same class.

Emily. Pray, give us some example of this?

Mrs. B. In re-production, for instance, the organ of most importance is the embryo; next to that the stamens and the pistils, which, taken collectively, are no less indispensable than the embryo, for without them it cannot receive life. Then follow the integuments which protect the embryo; and next those which guard the pistils and the stamens; after these come the accessary organs, such as the nectary. You see that I have already given five different degrees of importance to the organs of re-production.

1451.—How does Mrs. B. answer her? 1452.—What comparison does Mrs. B. make to illustrate the subject? 1453.—How is this to be applied to vegetable physiology? 1454.—In re-production in what order of importance are placed the organs, and how many of these organs are thus named?

Emily. But must you not also arrange, in a similar order of gradation, the different points of view under which a plant may be considered?

Mrs. B. No doubt; and, for this purpose, you must be guided by the rules we used in forming the different genera. The most important of which consists in carefully observing the symmetrical position of the organs in different plants. The natural method of classification consists in studying the details of the symmetry of the organs, in the same manner as mineralogy is founded, on the regular symmetrical laws of crytallisation.

Emily. All this appears to me very ingenious in theory, but difficult in practice. Supposing that I were capable of classing the vegetable kingdom according to this order of different organs; what proof should I have that I was following the right method?

Mrs. B. You might afterwards class the vegetable kingdom according to the organs of nutrition, and you could then compare the two arrangements. Now, if, in following two methods, each founded upon a set of different organs, the same plants are to be met with in the same class, is it not infinitely probable that the mode of classification you have adopted is the true one?—the image of what really takes place in Nature? Thus, the natural order of botany is that in which you obtain the same result, whether the vegetable kingdom be classed according to the organs of re-production, or to those of nutrition. More importance is usually attached to the organs of re-production, as being the most numerous and the most varied; the classification is, therefore, first made with reference to them, and afterwards with reference to the organs of nutrition: the latter of which serves to verify the former.

Emily. It is like making a proof in arithmetic: but is not this very difficult to reduce to practice?

Mrs. B. I do not deny that it is sometimes attended with difficulty. In botany, as in every other science, no

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1455.—In what does Mrs. B. tell Emily we must be guided by the rules used in forming the different genera? **1456.**—In what consists the natural method of classification? **1457.**—How else, afterwards, might the vegetable kingdom be classed? **1458.**—What inference is drawn from the results of two different arrangements? **1459.**—What is said of classification as depending on the comparative importance of the organs of re-production and nutrition?

progress can be made without labor and preseverance:—much yet remains to be done, but it is gratifying to have a great end in view: it elevates the mind, and renders the details of a science interesting. The difficulties that occur in classification arise, either from our not yet knowing all the plants that exist, or from our limited faculties often preventing our acquiring a competent knowledge, of the nature and internal structure of their organs. Time may overcome the former of these difficulties; but the latter will probably never be completely conquered. Sometimes, for instance, the organs of plants which ought to be symmetrical, are not all developed; at others, they are joined together so that their number cannot be distinguished:—this we have called soldering. Sometimes they assume unusual form and dimension: this is called degeneration of the organs. These three causes, considered either collectively or separately, often deceive botanists in regard to the real nature of the vegetable organs, but, by dint of observation, the truth is gradually brought to light.

Emily. We should, no doubt, be incapable of understanding in detail the results of the principles you have explained to us; but cannot you give us some slight idea of them?

Mrs. B. I will make the attempt, at least. You may recollect learning the other day, that genera was composed of those species most nearly resembling each other. Now, by means of the principles I have just laid down, it was soon discovered, that in a certain number of genera the organs of re-production were very analogous: it was then ascertained, that the organs of nutrition of these same genera, also bore a striking resemblance to each other. These genera were then united, as it were, in a group, and denominated a *family*. Thus the five thousand genera form about two hundred and fifty families.

Caroline. Families of plants, then, are nothing more than a numerous collection of genera resembling each

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1460.—What is needful for progress in botanical science? 1461.—From what arise the difficulties that occur in classification? 1462.—What is said of overcoming these difficulties? 1463.—What three causes have often deceived botanists in regard to the nature of vegetable organs? 1464.—What does Mrs. B. tell Emily she must recollect as having been learnt? 1465.—By means of those principles what is soon learnt? 1466.—To what number of genera, and of families are plants reduced?

other. But, then, *genera*, in the sense in which it is here taken, means not *families*, as it ought to do, from its Greek origin, but merely branches of families: is not this liable to create confusion?

Mrs. B. I think your remark very just: using the word in some measure in a different sense from which it is derived appears to me an imperfection in this mode of classification.

Emily. Families are to genera, what genera are to species; or, to follow up the comparison you made between plants and the human species, we might say, that families of plants were like nations of human beings; and that all these families collectively form the vegetable kingdom, in the same way as all the nations of the earth form the population of the world.

Mrs. B. Exactly so; and the families of plants, like the different nations of the world, have each their peculiar characters and habits. Thus, independently of the analogy between their organs, plants of the same family often resemble each other in their mode of life, and in their peculiar properties. For instance, all the *Ficoideæ* have succulent leaves, suffer from moisture, and inhabit climates where the sun's rays are powerful; then, the *Valvaceous* family bear leaves of an emollient nature; the embryo of all the *Euphorbiaceæ* is of an acrid nature; the roots of the *Valerianeæ* have all a particular smell, and act in a peculiar manner on the nervous system; the Cruciform family is, in all its branches, antiscorbutic. In a recent voyage, undertaken with a view of discovering the spot where the celebrated La Peyrouse was shipwrecked, the whole of the crew was afflicted with a scorbutic complaint, which was greatly relieved by feeding on an unknown plant of the cruciform family growing on the coast of New Holland—a remedy which was pointed out to them by the botanist attached to the expedition. There is another point of resemblance between plants of the

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1467.—What does Caroline say of the meaning of the terms—Genera, and Families, as used in Botany? 1468.—What does Mrs. B. also say? 1469.—How does Emily follow up the comparison? 1470.—What does Mrs. B. say of the peculiar characters and habits which pertain to families of plants? 1471.—What does she say of the Ficoideæ, and the Malvaceous family? 1472.—Of the Euphorbiaceæ, the Valerianeæ, and the Cruciform family? 1473.—What anecdote is related respecting the voyage made to New Holland?

same family, I have before mentioned; which is, that these alone are susceptible of being grafted on each other.

Caroline. These analogies are extremely curious; and I understand now, perfectly, how much superior your method is to those which merely indicate the name: for when I know that a plant has four stamina, it teaches me nothing further; whilst the knowledge that a plant belongs to such or such a family makes me acquainted, in a great measure, at least, with its structure and its properties.

Emily. I am glad, Caroline, that you are come round to my opinion; for I felt a sort of instinctive conviction that it was in analogies of this description that the interest of the study of Nature consisted. But pray, Mrs. B., is it not possible to group families together in the same manner as you have done genera?

Mrs. B. Yes; there is still another step in classification, which brings us to the three great distinctions with which you are already acquainted.

First. That class of vegetables called *Dycotyledons*, relative to their organs of re-production; and *Exogenous*, relative to their organs of nutrition. This is by far the most numerous of the three classes, comprehending about two thirds of the vegetable kingdom.

Secondly. The vegetables called *Monocotyledons* or *Endogenous*, according as you allude to their re-productive or nutritive organs.

Thirdly. The class called *Acotyledons*, from being destitute of cotyledons, are also called *Cellular*, because their nutritive organs have no vascular system. To complete the comparison we have followed up, these three great classes may be considered as the three great continents of the world; the different families of plants as the various nations into which these continents are divided; the genera represent the families of each nation; and the species must be considered as the unity of the scale. This comprehends the whole system of classification, which every day becomes more extended and more perfect.

1474.—What does Caroline say of the advantages of this mode of studying Botany? 1475.—What makes the first of the three great divisions of vegetables here pointed out; and how numerous is this division? 1476.—What make the second division? 1477.—What make the third division, and what is said of those which compose it?

Emily. Let me see whether I can make out this genealogical table of plants.

The three grand divisions give birth to 250 families.
These 250 families produce 5000 genera.
And the 5000 genera, 60,000 species.

Mrs. B. The species, in their turn, give rise to races, varieties and variations; but we shall not enter upon these subdivisions at present, as they are the result of an artificial, rather than of a natural, mode of propagation; and, indeed, their numbers are both too great and too variable to be reckoned in a table of classification. There are, for instance, no less than fifteen hundred varieties of the vine, and five hundred of the pear-tree: it is true that other plants do not afford so great a number.

Caroline. If they did, you might almost as well undertake to count the individual plants as to number them. But do not the number of species also increase by the discovery of new plants?

Mrs. B. No doubt they do. Since the death of Linnæus, about fifty thousand new species have been discovered, making, on an average, one thousand species every year.

The numbers, therefore, which I have given you, are intended only to enable you to form a general idea of the present state of the vegetable kingdom; but they cannot be considered as permanent.

This explanation will, I hope, enable you to understand the basis of the *natural classification,* the details of which can be acquired only by study and practice.

Caroline. But how can we study this system, since the English botanists follow that of Linnæus?

Mrs. B. Generally they do, but not exclusively. We already possess two excellent English works: the one called the *Flora Scotica,* by Mr. Hooker, in which the plants are classed both according to the system of Lin-

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1478.—What is the genealogical table of plants, as she calls it, which Emily makes out? 1479.—What further divisions are there in the vegetable kingdom? 1480.—How many varieties of the vine and pear tree are there? 1481.—Since the death of Linnæus, how many new species of plants have been discovered? 1482.—What is said of the number given in this work? 1483.—Of the Flora Scotica?

næus and that of Jussieu; the other, the *British Flora*, very recently published by Dr. Lindley, Professor of Botany in the University of London, in which the plants are arranged according to the natural method. You may afterwards consult works of a more general description which will carry you still further; and, when once you are accustomed to investigate the affinities of plants, your eye will enable you to guess, as it were, a great portion of what remains to be learnt.

Emily. If these affinities are so evident to the eyes of a botanist, whence comes it that they have only been so recently studied!

Mrs. B. Botanists have long been acquainted with the affinities of plants growing in great numbers in Europe. Thus, ever since botany has become a science, the Cruciferous, Gramineous, Umbelliferous families, and several others, have been distinguished. But those families which are dispersed over every quarter of the globe could not be classed until the analogy of the different plants had been discovered and studied; and travellers, ignorant of botany, are incapable of recognising the affinities of plants they have never studied.

Emily. What an interesting study the comparison of plants of different countries must be!

Mrs. B. Undoubtedly it is. This study is called botanical geography; and, if you wish to acquire some idea of it, we will make it the subject of our next conversation.

Emily. With the greatest pleasure.

CONVERSATION XXIV.

ON BOTANICAL GEOGRAPHY.

Mrs. B. At our last interview I promised to give you some idea of the laws which appear to regulate the distribution of plants on the surface of the globe.

Caroline. Yes; this is the study you called Botanical Geography.

1484.—Of the British Flora? 1485.—What families of plants were first distinguished. 1486.—What is said of others not so soon known?

Mrs. B. It is a science of very recent date; indeed, it is only within the last few years, that it has been cultivated wtih any degree of success. It is founded entirely on the distinction made between the *habitation* and the *station* of plants.

Caroline. I do not understand what you mean by this distinction. Are there two modes of indicating the country of a plant and the spot in which it grows?

Mrs. B. Precisely so. For instance, when you say that the tulip-tree grows in America, you point out what, in botany, is called its *habitation;* when you say that it grows in marshy districts, you intimate its *station.* Thus, the term habitation relates to the geographical distribution of plants on the face of the globe, while station denotes the peculiar localities in which they are generally found.

Emily. I understand your meaning perfectly; but I cannot conceive that any degree of importance can be attached to this distinction.

Mrs. B. I will explain it. You will readily admit that the nature of the soil, the aspect, the degree of moisture, &c., is sufficient to account for particular plants growing in certain spots rather than in others. Their *station* is thus explained by physical laws, with which we are more or less acquainted. The causes of their *habitation* are, on the contrary, perfectly unknown to us. Were you, for instance, to find in America (a circumstance not at all improbable) a marshy district, perfectly similar both in regard to temperature, moisture, and the nature of its soil, to another marshy district in Europe, the two marshes would be peopled with plants of a very different description. The cause of this singular phenomenon appears, therefore, to have existed prior to the actual state of the globe, and is consequently impossible to explain.

Emily. It is true that the tulip-tree, of which you were just speaking, grows very well when transplanted to Europe; and I have heard that our walnut-trees thrive equally well in America: but neither of these trees grow

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1487.—On what is the science of botanical geography founded? **1488.**—What explanation is given of the use of the terms, habitation and station, in botany? **1489.**—Emily says she does not understand the propriety of this distinction—what further explanation of station is given? **1490.**—And what further is said of habitation? **1491.**—What is said of transplanting the tulip-tree?

spontaneously out of their natural country, or, as you call it, their habitation.

Mrs. B. Well, then; botanists, after having studied the surface of the earth under this point of view (as far as their imperfect knowledge of barbarous countries would admit,) have divided the globe into twenty districts, which they named *botanical regions*. Each of these regions possesses a vegetation peculiar to itself, plants of the same species being seldom found growing (naturally I mean) in different regions.

Caroline. How are these regions to be distinguished from each other?

Mrs. B. Those whose limits are the most correctly determined are separated from each other by a vast expanse of sea.

Caroline. Why a vast expanse? Would not a narrow sea, like the Mediterranean, serve to define the limits equally well?

Mrs. B. No; narrow seas do not constitute a limit to botanical regions. There is scarcely any difference between plants which grow in the north of France and those growing in England, or between the plants on the two opposite shores of the Mediterranean. Nor do Islands in the vicinity of continents constitute a boundary, as they have generally the same species of vegetation as the neighboring continent; while Islands situated at a considerable distance from continents have often quite a different vegetation. For instance, the plants which grow naturally in St. Helena and the Sandwich Isles, are almost all different from those of any of the continents.

Emily. Then I conclude that large tracts of continent, also, must differ in the nature of their vegetation.

Mrs. B. It is so in general; but as the old and the new world approach very near to each other, if they are not actually united towards the north pole, the plants of the northern regions are nearly the same in the three continents; and the further you recede from the pole, the more distinct the different regions become in regard to vegetation.

1492.—Into how many Botanical Regions is the earth divided? 1493.—How are these regions distinguished? 1494.—What is said of seas, like the Mediterranean as seeming to define these limits? 1495.—And of islands; and what ones are named? 1496.—What is stated of the similarity in the three great northern continents, or divisions of the earth?

Emily. Are there any natural limits which separate different regions in the same continent?

Mrs. B. There are, but they are less defined than those separated by seas; so that there is a greater mixture of plants in these regions. Their natural limits in continents are, for instance, either extensive sandy deserts, such as those of Sahara, which separate northern Africa from Senegal, or chains of high mountains, which oppose an insuperable barrier to the conveyance of the seed by natural means; or, again, vast salt-plains, which prevent the germination of seeds.

Emily. But are there not a variety of means by which plants may be conveyed from one region to another?

Mrs. B. No doubt; and that accounts for plants appertaining to different regions often being found growing in the same. Rivers, for instance, and high winds, convey seed from one country to another; birds of passage transport the seed on which they feed; animals carry them in their wooly or hairy coats; and, finally, man conveys seed wherever he goes: sometimes voluntarily, as corn and potatoes, which he has disseminated all over the known world; at other times, unintentionally. And it is owing to this casual transport, that the plants, and even weeds, of most of our villages, have found their way to America.

Caroline. Like Robinson Crusoe, when by shaking the dust out of a bag, he produced a crop of corn.

Mrs. B. Very true; but men have even gone further, and conveyed seeds from one part of the world to another, much against their intention or inclination; such as the seeds of the wild poppy and corn-flower, which can never be completely separated from the grains of corn. But, independently of these emigrations, it must be confessed, that there is a small number of similar plants existing in different regions, without the possibility of explaining how they could have been conveyed from one region to another.

Caroline. This is quite a new idea to me: I always thought that a great number of the same plants were to be

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1497.—What is said of natural limits in the same country? 1498.—What instances are named? 1499.—By what different means are the seeds of plants carried from country to country? 1500.—What seeds have been carried by men against their intention? 1501.—What is said, independently of of these emigrations, of the existence in different countries, of similar seeds?

found in countries very distant from each other. I have heard of the American elm, the apricot of St. Domingo, and many other plants bearing the same names, both in Europe and in America.

Mrs. B. This is owing, in a great degree, to the first colonists who settled in America being ignorant of botany, and giving European names to plants, which, in fact, were very different from those whose names they assumed.

Emily. I suppose they considered it as a sort of tribute paid to their native country; just as they gave the names of New York and New Holland, to countries very different from those of Europe.

Mrs. B. Another reason may also be alleged. It often happens that different species of the same genus inhabit different regions; for instance, the *Vaccinium Macrocarpum*, which we call Canadian cranberry, is of a different species from the *Vaccinium Oxycoccus*, or English cranberry, which we eat dresed exactly in the same way. Thus, also, the oak, the pine, and the maple, of the United States, are of a different species from those which bear the same name in Europe.

Emily. It appears, then, that there is no sort of connection between the classification of plants and their geographical distribution.

Mrs. B. There is some slight connection, but it is so variable that it is little to be depended on. Thus while certain families and certain genera are dispersed all over the world, others are confined to a single region; all the *Cacti*, for instance, come from America; the *Aurantiaceæ* from India or the neighboring countries; the *Epacrideæ* from New Holland; and, amongst the genera, there are many, every species of which inhabit the same region. Thus, all the *Cinchonas* are derived from South America; the *Gorterias* from the Cape of Good Hope, &c.

It often happens that different genera bear so near a resemblance to each other, that the various species of the same genera or families are divided, as it were, between them. For instance, a portion of the *Pelargoniums* are

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1502.—What does Caroline say she has heard in reference to this subject? **1503.**—To what is this owing? **1504.**—How does Emily account for this? **1505.**—What is another reason and what examples are given by Mrs. B.? **1506.**—Is there any connection between the classification of plants and their geographical distribution? **1507.**—What are the three first examples in illustration given by Mrs. B. **1508.**—And what is said of the Cinchonas and Gorterias?

situated at the Cape of Good Hope, while another portion of the same family grows in Van Dieman's Land. Botanists have of late paid great attention to this subject; but the results of their researches can be considered only as temporary, as it will ever be liable to change so long as unknown plants remain to be investigated.

Emily. Cannot you give us some idea of the result of their researches?

Mrs. B. It has been calculated, for instance, that in almost all the botanical regions of the world one sixth of the plants are monocotyledons; and that, in regard to the other two classes; the number of dicotyledons increases as you approach the equator, and that of the acotyledons, on the contrary, as you draw nearer towards the pole. This rule does not prevail in islands situated at a great distance from any continent: in these the proportion of monocotyledons is greater, and that of the dicotyledons less, than is usually found in continental regions of the same latitude.

Caroline. You do not mean to say that the same proportion of monocotyledons exist in Europe as in Asia—in cold northern countries as in tropical climates? To judge from the views I have seen of India, the greater part of the trees are of the family of Palms.

Mrs. B. A few of such magnificent trees make a great show in a landscape; but reccollect that all our corn and grasses are monocotyledons. The difference between this class in England and in India consists, not in the number, but in the size, of the plant. The vigorous vegetation of tropical climates produces monocotyledons of stupendous dimensions, while the chilling temperature of northern regions checks their growth; and if we go beyond the gramineous family, it is but to produce lilies, tulips, hyacinths, and other imperfectly-developed bulbous roots. It is only in the most southern parts of Europe that a few straggling palms denote the approach to a more vigorous region of vegetation.

Caroline. But tropical climates produce corn and grasses as well as palm-trees.

1509.—What else often happens of the different genera? 1510.—Emily asks what is the result of the researches of botanists in this part of the science—What is the answer? 1511.—Where does this rule not prevail? 1512.—In objection to Mrs. B. what question does Caroline propose? 1513.—What is the reply? 1514.—What is said of the growth of the palm in Europe?

Mrs. B. True, but in much less quantity; herbaceous plants require less heat and more moisture than is to be met with in such climates. The number of ligneous, compared to that of herbaceous plants, universally increases as you approach the equator.

Emily. Does this increase and decrease proceed in a regular progression from the equator to the poles?

Mrs. B. No: the number of annual plants, for instance, is very considerably greater in temperate than in either the tropic or frigid zones. The delicate structure of those plants render them incapable of resisting either the dry heat of the tropics or the severe cold of the polar regions.

Emily. We have also the advantage of the most beautiful and delicate colors in the vegetation of spring! while I have heard that, both in the polar and tropical regions, the spring-leaves are of a much darker and more sombre color.

Mrs. B. Now that you have acquired some idea of what is meant by a botanical region, let us observe how the plants are distributed in one of these regions, and why different plants prefer different localities.

You will easily understand, that every plant, according to its particular structure, requires the concurrence of many circumstances in order to be brought to perfection.

Emily. No doubt. It is evident that the same soil, or the same degree of heat, light, or moisture, cannot be equally good for all plants.

Mrs. B. When plants shed their seed, it is more or less dispersed by wind, rain, or other natural agents, and is finally deposited on a soil which may or may not be favorable to its germination. Thus, in particular spots, a sort of struggle takes place among the different species of vegetables which it produces. The most vigorous plants, and those best suited to the nature of the soil, make the greatest progress, and ultimately exclude the others.

1515.—Of the growth of corn and grasses as well as palms in tropical climates what is said? **1516.**—Emily asks—if this increase and decrease proceed in a regular progression from the equator to the poles—What is the reply? **1517.**—What does Emily say of the color of leaves? **1518.**—What is needed that a plant be brought to perfection? **1519.**—What circumstances, which may be favorable or unfavorable to germination, are mentioned? **1520.**—In some particular spots, what takes place among the different species of vegetables?

Caroline. So that in the vegetable, as well as in the animal kingdom, the strong oppress the weak, and a contest takes place even among flowers, to all appearance the symbols of peace and harmony.

Mrs. B. I am sorry to spoil your poetical ideas of vegetation ; but such is the law of Nature. You will now understand, that the richer the soil the greater is the number and variety of plants that can grow in it. Thus, in tropical climates, the forests are composed of a much greater variety of trees than in the temperate zone ; and, as you approach towards the polar regions, the number of different plants gradually diminishes.

Emily. It is, perhaps, on this account that in the highlands of Scotland we meet with immense tracts where no plant is to be seen growing but heath or furze.

Mrs. B. Precisely. These species of plants being of a hardy nature, and able to live in a soil from which most other plants are excluded, meet with no competition, and establish a colony apart from other plants. Such plants are called by botanists *Social,* from their habits of living together in societies.

Caroline. I think they should rather have been called unsocial, from their excluding plants of a different species.

Mrs. B. They at least deserve the name of inhospitable: the *Potamogetons,* which grow in stagnant waters, Kelpwort (*Salsola,*) and Saltwort (*Salicornia,*) which grow in salt districts, are of this description. There are some plants which become social from their mode of propagation ; those, for instance, which have spreading roots, such as the *Hieracium Pilosella,* or Mouse Ear Chickweed. Plants, on the contrary, whose seeds are crowned with a tuft, which enables the wind to have more power over them, are dispersed to a great distance : between these two extremes there exists a great variety of intermediate degrees.

There are some plants which, so far from excluding those of a different species from their society, seem to take delight in the neighborhood of trees to which they them-

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1521.—What is said of the number and variety of plants that grow in different climates? 1522.—In the highlands of Scotland what may be found? 1523.—Why do heath and furze grow there? What are such plants called? 1524.—Of this description what other plants are mentioned? 1525.—What is mentioned of the Hieracium Pilosella; and of plants whose seeds are covered with tuft? 1526.—What plants seem inclined to grow in the neighborhood of trees to which they bear no resemblance?

selves bear no resemblance: thus, the *Salicaria* loves to grow at the foot of the willow: the *Monotropa*, at the foot of the pine; the *Saxote*, to grow amongst oats.

Emily. What can be the reason of this singular kind of attachment of one species of plants for another?

Mrs. B. Several have been assigned: first, that plants of different species frequently require the same soil; the next (of a more doubtful nature) is, that the exudations of some plants may promote the growth of others of a different species; a third reason alleged is, that certain plants often serve to protect others of a different species, as hedges and bushes protect the creeping plants which grow between their branches.

Emily. It appears, then, that we can in some degree explain that prodigious mixture in the vegetable kingdom, in which at first I thought there was no sort of order.

Mrs. B. There is always order in the works of Nature; and what appears to us disorder is the result of different laws acting at the same time. By following the mode of reasoning I have pointed out to you, and by constantly comparing the structure and the habits of plants with the nature of the soil in which they grow, a great number of curious facts may be explained. I am glad to have drawn your attention to this subject; it will be a source of amusement in your walks: and the greater the number of plants you become acquainted with, so as to be enabled clearly to distinguish their different species, the more interesting will your observations prove.

CONVERSATION XXV.

ON THE INFLUENCE OF CULTURE ON VEGETATION.

Mrs. B. Let us now examine to what extent the natural state of plants can be modified by the art of man. For this purpose it will be necessary for me to make you acquainted with certain differences which exist in plants of the same species.

1527.—What reasons have been assigned for this singular fact in botanical science? **1528.**—What advantage does Mrs. B. think will result to her pupils from the knowledge of botany they are acquiring? **1529.**—What is the subject of the 28th Conversation?

A species, you recollect, comprehends all those plants which bear so great a resemblance to each other that we may reasonably suppose them to be descended from the same parent stock. But, independently of this general similitude, each species admits of various shades of difference, some of which are strongly marked, and of a permanent nature; others more slight and evanescent: hence spring the three modifications of *Races*, *Varieties* and *Variations*. Several *races* derive their origin from the same species; and the points in which they differ are of so decided a character, that they are continued from the parent-plant to its offspring, or, in other words, when it is propagated by seed.

Varieties are a subdivision of races; in which the points of difference are of so slight a character, that they are continued from one individual to another only when the plant is propagated by subdivision; that is to say, by grafting, budding, or layers, but are obliterated when it is raised by seed.

Variations are the feeblest of all deviations: they originate in the peculiar circumstances or situation of the plant, such as peculiarity of soil, temperature, &c., and are susceptible of being continued to successive individuals only if placed under similar circumstances.

Now, the art of man has great influence in varying and multiplying these several modifications of species. If, for instance, the pollen of the flower of one species be made to fall on the pistils of another species, one of two things may happen: either the flower will produce no seed; or, if it produce seed, the plant which results from it (which is called a Hybrid) will partake of the form and nature of the two plants from which it springs; and hybrids very rarely produce any seed.

Caroline. It is then, I suppose, only performed as a curious experiment, since the seed is lost, and nothing is gained in exchange.

Mrs. B. True; but the result is very different, if, in two plants of the same race but of different varieties, the pollen of one be made to fall on the pistils of the other, the blossom will in general bear fruit, and thus a new va-

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1530.—What does a species comprehend? 1531.—What less general shades of difference is there in plants? 1532.—What is said of *Races?* 1533.—Of *Varieties?* 1534.—Of *Variations?* 1535.—What is Hybrid, or how is it produced? 1536.—What is said of the mixtures of two plants of the same race, but of different varieties?

riety will be produced, differing from those from which it drew its origin. Let us suppose, for instance, that there were but two varieties of cabbages in nature, the one spherical, the other spreading : by the intermixture of the pollen of these two, a third variety would be produced ; and by continuing the process between these three varieties, ten, twenty, or thirty new ones would result. But as these varieties bear seed capable of re-production, it is, in fact, new races which are formed.

In Belgium, the horticulturists, with the most patient perseverance, produce, by this process, a great number of new varieties of fruit trees, which they propagate by seed, and thus give birth to new races ; but this is extremely tedious, for it is many years before the fruit tree raised from seed, is capable of bearing fruit.

Emily. This period might be accelerated by grafting ; but then that process would alter the nature of the new variety of fruit.

Mrs. B. Certainly ; the Dutch are celebrated for the beauty, or rather the variety of color, of the tulips they have thus introduced. These flowers change their color during the first seven years, they afterwards never vary : this renders a course of experiments, with a view to produce certain colors permanently, much more tedious, and, consequently, more expensive than with most other plants; and the Dutch horticulturists prosecuted their labors with such enterprising zeal, and the passion for flowers was, in that country, carried to such excess, that it was thought requisite to enact a law, forbidding the sale of a tulip for above the sum of four hundred pounds.

Emily. Is it possible that any one would go to so great an expense for a simple flower ! It is by these means, I suppose, that many fruits and flowers have of late years been so much improved. The great variety of beautiful geraniums and gigantic strawberries are, doubtless, the result of similar experiments ; but the flavor of the fruit does not, I think, correspond with its size ; I even doubt whether the bulk is not increased at the expense of the flavor.

Mrs. B. It will seem to be diminished to the palate,

1537.—How is this illustrated in the case of the cabbage? 1538.—What is done by horticulturists in Belgium? 1539.—For what are the Dutch celebrated? 1540.—What have they accomplished with the tulip? 1541.—What does Emily think of these artificial means for improving fruits and flowers?

if the same quantity of flavor be diffused over a greater bulk of fruit; but I believe that the horticulturists consider that they have improved the flavor, as well as the size of the fruit.

The influence of culture on variations results from its influence on the soil, and the quantity and quality of the nourishment afforded to plants. Hence some parts of a plant may be made to prosper more than another; the stem more than the foliage and fruits, if timber be required; the leaves more than the seed, if grasses; or the fruit more than the leaves, with most fruit trees. A change of color may also be produced. Thus the Hydrangia, when first brought from the Isle of Bourbon, was blue; in this country it is commonly of a pale pink, and it is the soil principally which has effected this change; for if cultivated in a ferruginous soil, similar to that of its native land, the blue color is re-produced. Pink flowers may be thus changed to blue or white; but cannot be made to assume a yellow color; thus the Hydrangia, or the Campanul may be varied from pink to blue or white, but you never see them of a yellow color.

Emily. That is true; Hyacinths are also pink, blue, or white, but they are seldom of a yellow color.

Mrs. B. They are the only flowers which form an exception to the rule, being sometimes yellow.

The neighborhood of the sea produces a variation in plants, rendering them more succulent or fleshy.

Grafting also modifies the variations of plants. The art of pruning has very considerable influence, by modifying the direction of the sap; but its effect, however great on the individual plant, produces no change on its successors.

Trees are pruned with a view to improve their beauty, their health, or their produce. Trees were formerly cut and trimmed into all kinds of grotesque figures, according to the tasteful ideas of beauty of our ancestors. Since this barbarous system has been exploded, that of heading young trees, in order to thicken the branches and foliage, has been introduced; but this, we have agreed, injures the natural port and character of a tree; and all that is

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1542.—What does Mrs. B. say on the same subject? 1543.—What does she say of the superior growth of particular parts of the same plants? 1544.—What instances of change of color are mentioned? 1545.—How are plants effected by the neighborhood of the sea? 1546.—And by grafting? 1547.—With what view are trees pruned, and how were they formerly done?

allowed in the present times, in order to improve the appearance of a tree, is to strip off the lower branches, in order to prevent its assuming the form of a bush. This operation should not be performed too soon: the stem, while young, requires the aid of these lower branches to carry on the process of vegetation, and supply it with nourishment: they pour their cambium into the stem at its base, and thus assist in increasing its vigor.

Emily. Yet, would not this operation become dangerous, if long delayed? for the larger the lower branches are suffered to grow, the more serious will be the effect of their amputation.

Mrs. B. The proper time for lopping them is, when the tree has attained sufficient vigor to enable it to recover from the wounds, in the course of the year.

Resinous trees suffer from pruning, by losing too much of their resinous juices: fir trees should never be pruned; but if planted in groups, as we see them growing naturally, the lower branches, being deprived of light and air, dry up and perish: it is thus that Nature prunes them without the infliction of a wound, from which the resinous juices would flow, to the great detriment of the plant.

In regard to the pruning, which relates to the health of plants, not only should all the dead branches be carefully removed, but the pruning knife must penetrate into the quick of the wood. It is advisable, also, to cut away all the parts which are diseased, as these seldom recover, and would continue, during a few years of sickly existence, to absorb, uselessly a portion of the sap, and very probably, during this period, to communicate their malady to the contiguous branches.

All branches seriously injured by hail, should be immediately removed; they will then rapidly shoot afresh, and, in the course of a few weeks, their loss will not be perceived.

Emily. Greenhouse plants must require a great deal of pruning, for as their roots cannot grow freely in search of food, the branches must be diminished, in order to correspond with their limited quantity of nourishment.

1548.—What is the present mode of improving their appearance? 1549.—Why should this operation not be performed too soon. 1550.—Of pruning resinous trees what is said? 1551.—How should pruning be done, which relates simply to health? 1552.—Of diseased parts what is said? 1553.—And of branches seriously injured by hail?

Mrs. B. True; both root and branch require pruning annually, when the plants are fresh potted. But observe that the gardener takes care to atone, as far as lies in his power, for the contracted sphere in which they vegetate, by affording them as much food as can be contained in so limited an extent of soil.

Pruning fruit trees is done with the view of either increasing the quantity, or ameliorating the quality, of the produce. It consists in retarding the descent of the cambium, in order that by remaining longer in the branches, it may nourish them more abundantly. For this purpose, the branches which grow vertically should be pruned, because the sap, descending through them straight downwards, moves with greater velocity than when it descends obliquely, as it does in laternal branches.

It has sometimes been found advantageous to bend down the vertical branches, in order that the cambium should be compelled to rise, in its return from the extremity of the branch; and the time required to overcome this difficulty retards its march, and enables the branches to absorb more nourishment from it, during its passage.

Espaliers are usually trained in the form of a fan, by cutting away the central stem: or the stem may be preserved, provided that the branches be trained laterally; for it is in these, rather than in the stem, that it is essential to diminish the velocity of the cambium.

You recollect my having already made you acquainted with three species of buds: those which produce fruit; those which develope leaves only; and those of a mixed nature, containing both fruit and leaves.

Caroline. Yes; and we observed that the more fruit buds escape the pruning knife, the greater will be the crop of fruit.

Mrs. B. Care should be taken, however, not to leave more fruit buds on the tree, than the sap will be able to bring to perfection, else the quality of the fruit will be deteriorated. Good gardening consists in preserving as many fruit buds, as the tree can nourish without exhaustion;

1554.—How should greenhouse plants be pruned? **1555.**—With what view are fruit trees pruned, and in what does it consist? **1556.**—What advantage results from bending down the branches? **1557.**—How are espaliers usually formed? **1558.**—What three species of buds are enumerated? **1559.**—In what consists good gardening.

for if you force a plant to labor beyond its strength, either the fruit will not ripen, or its size and flavor will suffer.

Caroline. But this pruning, with a view to improve the quality of the fruit at the expense of the quantity, is an unnatural state of vegetation, which, I should suppose, would eventually be prejudicial to a tree.

Mrs. B. I cannot consider it so: the finest trees and the choicest fruit, are those in which art has judiciously assisted and modified the efforts of Nature. We contribute to the health and general prosperity of the tree by preventing it from bearing an excess of fruit; and we make amends for the diminution of quantity by the increase of its size and flavor

CONVERSATION XXVI.

ON THE DEGENERATION AND THE DISEASES OF PLANTS.

Mrs. B. We shall preface the history of the diseases of plants by that of the degeneration of their organs, which often undergo a species of metamorphosis, and, instead of being developed in the usual manner, degenerate into monstrosities.

There are several causes which produce this effect on plants: 1st. The natural soldering, or cohesion, of the parts. You frequently see the leaves of branches, the petals of flowers, and even fruits which unite, forming double leaves, double flowers, and double fruits.

Such cohesion sometimes regularly occurs. The single petal which forms the corolla of many flowers, such as the convolvulus, is composed of the union of several others; but as it is not unfolded until after the junction is completed, we are led to consider it as a single petal; and such flowers are called in botany monopetalous.

Emily. But where this union regularly occurs, it should, I think, be considered as the natural state of the plant, and not as a monstrosity. Pray, how does it take place? Is it a species of grafting one petal upon another.

Mrs. B. No; it is rather a simple adhesion than a

1560.—How are the finest trees and the choicest fruits produced? **1561.**—What is said of the degeneration of the organs of plants? **1562.**—What is the first of the causes which produce these effects on plants?

continuity of vessels through which the sap passes. The petals in which this adhesion so frequently occurs have no liber; and this, you know, is essential to the process of grafting, as it is through the vessels of the liber that the cambium descends.

Another species of monstrosity arises from a want of vigor in the plant to bring all its parts to maturity. That which most commonly fails is the seed, which is produced in such abundance, and requires so much nourishment to ripen, that the greater part perishes in the bosom of the flower. The blossom of the horse-chesnut, for instance, contain six seeds, enclosed in three cells; but one only, or at most two, come to maturity. It is the same with the oak; it has six seeds, but only one acorn is brought to perfection.

Caroline. And to what cause is the want of developement owing? If the plant be incapable of ripening so many seeds, why has Nature furnished it with so useless an abundance?

Mrs. B. The causes of these abortions are probably numerous; but the principal one is, no doubt, a deficiency of nourishment. Yet so far from inferring that such failures imply a want of regularity in the laws of nature, it is to them that we are indebted for one of the most efficient means of ascertaining the order which reigns in the natural world.

A third species of monstrosity results from a degeneration of the ogans, which disables them from fulfilling the purpose for which Nature originally designed them. Thus, in some plants, the leaves do not sprout, and the stem, receiving the nourishment which the leaves should have absorbed, swells out to a considerable size, and expands like leaves. The Xylophylla and the Cactus opuntia are constantly in this state. It is said, that the leaves of these plants bear flowers; but the fact is, they have no leaves; the flowers grow on the expanded stems.

Flowers having double blossoms are also classed among the tribe of monsters. This arises from the stamens being too abundantly nourished. They swell out, flatten, and

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1563.—What is metioned of the convolvulus as forming a specimen of this? 1564.—How does this union take place? 1565.—What is another species of this monstrosity? 1566.—What is said of the horse chesnut and the oak as furnishing instances of this? 1567.—What are the causes of these abortions, and what is said of them? 1568.—From what results a third species of monstrosity?

are converted into petals; hence the flower becomes double. Thus we have double roses, double stocks, double blossom cherry, &c. The process of this metamorphosis is very plainly discernible in the double hyacinth and the double tulip, where many of the stamens are completely transformed into petals: others, while expanding for that purpose, still partially retain their original form. As this metamorphosis never occurs but when the anthers have perished, it is probable that they are starved by the stamens absorbing the whole of the nourishment.

Emily. It is, I suppose, owing to the destruction of the anthers, that double flowers bear no seed. But why should such beautiful productions of Nature be stigmatised by the name of monster? It is considering beauty as a deformity.

Mrs. B. However disagreeable are the ideas commonly annexed to the term monster, the word simply implies a deviation from the common course of Nature. In the animal kingdom, such a deviation almost always excites disgust, and is associated with the idea of ugliness. Were there consciousness in plants, they might very possibly consider the unusual quantity of petals and the deficiency of anthers as a deformity; but we, who look upon a flower merely to delight our sight with its form and color, associate the idea of beauty to this unnatural state.

Another instance of degeneration is, when the petioles or foot-stalks are transformed into leaves. The Acacia, for instance, has six or eight pair of leaves, a number which diminishes every year, till at length the foot-stalk is wholly deprived of leaves; but receiving all the nourishment which was previously distributed to them, it expands, flattens, and is itself finally converted into a blade, resembling a leaf.

Emily. Though the acacia is not a very common tree in England, I have seen a great number on the Continent, but never observed the species of metamorphosis you describe.

Mrs. B. The acacia to which I allude is that of Arabia, which produces gum arabic, and is known in Europe only as a hot-house plant. It is the original and only

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1569.—How is this accomplished and what is an instance? **1570.**—From what arise flowers with double blossoms? **1571.**—How do the double hyacinth and double tulip illustrate this? **1572.**—What is said of the term monster? **1573.**—In the animal kingdom what is said of it? **1574.**—How does the case differ in the vegetable world? **1575.**—What is another instance of this degeneration? **1576.**—What is said of the Arabian acacia?

true acacia. The tree we cultivate under that name is derived from North America: it obtained the name of acacia from some resemblance between its fruit and that of the Arabian plant, and was distinguished from it by the title of *false* acacia: but as the American tree multiplied in Europe whilst that of Arabia was known only to horticulturists, the epithet false was dropped, and it now usurps the name which really appertains to the Arabian plant. Its botanical name is *Robinia.*

Instead of wholly disappearing, folioles often degenerate into tendrils, for want of sufficient nourishment. The flower-stalk, or peduncle, is also sometimes converted into tendrils. This occurs constantly in the vine. The plant at first shoots out abundance of large leaves and clusters of grapes, when, after a time, the food proves insufficient to support such a profuse vegetation; the new leaves, gradually unfolded, are of smaller dimensions, and the clusters of grapes contracted in size. Still nourishment is wanting, and the later shoots, incapable of developing either flower or leaf, are converted into tendrils. Is this an imperfection in the system of vegetation, or is it not rather a beautiful contrivance, to enable the plant, when it has sprouted all the branches it can nourish, to sustain these branches by means of the tendrils in which they terminate, and which cling to the first object capable of affording them support?

Emily. These organs, which you call degenerated, appear to me to serve a purpose no less useful than the functions they would have performed had they come to a state of perfection. But do all the various sorts of tendrils of climbing plants result from the degeneration of other organs?

Mrs. B. There is great reason to suppose so. The most common of these degenerations is the transformation of the young shoots of branches into thorns. When a plant shoots more branches than it can nourish, the most weakly almost wholly cease to grow. The scanty sustenance they receive serves, however, to harden and strengthen them: hence the tender extremity is converted into an indurated sharp point, capable of inflicting wounds, which you must often have experienced.

1577.—And of that of America? 1578.—And of the degeneration of the folioles and flower-stalks? 1579.—How is this seen in the vine? 1580.—What is the most common of these degenerations? 1581.—How is this effected?

Caroline. Is it not singular that these two last degenerations, resulting from a similar cause, should be so different in their effects? In the thorn the food hardens without extending the shoot, whilst in the tendril it is extended to a considerable length, and is extremely flexible and slender.

Mrs. B. Nature has so contrived it (though by means which are unknown to us,) no doubt, with a view to provide support for climbing plants, which are too weak to bear the weight of their produce; and where no such assistance is required, she has converted the abortive shoot into an arm of defence.

Emily. Would, then, these plants have fewer tendrils and thorns, if transplanted into a richer soil?

Mrs. B. No doubt; because a greater number of young shoots would be brought to perfection. M. De Candolle transplanted a wild medlar-tree, covered with thorns, into his botanical garden, and in the course of three years not a single thorn was to be seen upon it.

Emily. Yet I have never observed that the rose or the gooseberry bush lost any of their thorns by cultivation.

Mrs. B. They are not thorns, but prickles, which grow upon the rose, the bramble, the gooseberry, and many other plants; and these are quite of a different nature. The prickle is a natural appendage, which has no connection with the wood; it springs from the bark, and is peeled off with it; and since it does not result from the degeneration of any organ, it is not susceptible of being diminished by cultivation.

The peduncle of the grape terminates in a tendril, when the vine is loaded with as many clusters of fruit as it can bring to maturity. But in a very favorable soil, more grapes would be produced, and this transformation of the fruit-stalk takes place later, and probably less frequently.

Caroline. And may not monstrosity of organs be produced by plants having too much nourishment?

Mrs. B. Certainly; it happens, if the nourishment, instead of being equally disseminated throughout the plant,

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1582.—What question does Caroline ask in reference to these two last degenerations? **1583.**—With what view does Mrs. B. suppose nature has so contrived this singular phenomenon? **1584.**—What is related of Candolle respecting a wild medlar tree? **1585.**—What is said of the prickles which grow on the rose, the bramble, and the gooseberry? **1586.** What is said of the vine, when the peduncle terminates in a tendril?

partially increases the growth of any particular part, all disproportion of size among the relative parts, is a deviation from the regularity of Nature, and must be considered as deformity; but as it is much more common for plants to be under than over fed, the monstrosities which arise from the latter cause are of rare occurrence.

Though these various irregularities and metamorphoses are classed under the head of monstrosities, I am far from considering them as evils: I view these changes as advantageous to plants, and if naturalists rank them as imperfections in the system of vegetation, they are, by the beneficence of Providence, turned to such good account, that we cannot but estimate them as blessings.

We shall now proceed to consider the influence of culture on the diseases of plants. The botanical physician must not rest satisfied with studying the symptoms of a disease, for the same symptoms may be produced by very opposite causes: thus, plants turn yellow if they receive either too much or too little water; and, in order to afford a remedy, the cause of the malady must first be carefully investigated.

Caroline. And that must be very difficult: since, in examining the patient you cannot ask him any questions.

Mrs. B. Fortunately, the diseases of the vegetable kingdom are of a less complicated nature than those of animals.

The diseases of plants may be ranged under six different heads:—

1. Constitutional diseases.
2. Diseases arising from light, heat, water, air, and soil, improperly applied.
3. Diseases arising from contusions and external injury.
4. Diseases occasioned by the action of animals on plants.
5. Diseases proceeding from the action of vegetables on each other.
6. Diseases arising from age.

Variegated or party-colored leaves, such as those of the box and the holly, are classed as constitutional diseases.

1587.—If there is too much nourishment what will be the effects?
1588.—How does Mrs. B. consider the tendency of these irregularities?
1589.—How does she say the botanical physician must proceed?
1590.—Under how many heads may the diseases of plants be ranged?
1591.—What is the first? The second? The third? The fourth? The fifth? The sixth?

They arise from certain juices of plants, which, from some unknown cause, change their nature, and thus affect the color of the leaf. These changes are preserved if the plants are multiplied by subdivision, and even sometimes continued when propagated by seed.

The second class of diseases results from circumstances connected with the undue supply of elements, which are in themselves necessary to vegetation; such as temperature, light, water, air, soil, &c. If a plant has too much or too little light, heat, or water, it has no means of avoiding the excess, or of compensating for the deficiency.

Caroline. The poor plant, it is true, rooted to the ground, cannot, like an animal, fly the evil, or seek a remedy; it must patiently submit to it, and endure the diseases it entails: if the soil afford too much nourishment, it must continue feeding, and cannot stop when its appetite is palled.

Emily. Or, what is worse, and more frequently the case, when the soil does not yield a sufficiency of nourishment, it cannot seek it elsewhere, and famine must debilitate the roots, and diminish that vigor which would enable them to stretch out their fibres over a greater extent of soil.

Mrs. B. We have already entered so much into detail on the influence of light, heat, water, and soil, on plants, that I shall confine myself to recalling a few of the most essential points to your memory. Excess of light produces too much excitement; the oxygen escapes, and the carbon is deposited too rapidly; the plant vegetates in a fever, and the sap, incapable of supplying its wants, is exhausted; the plant withers, and the leaves fall off. There are two modes of remedying this disease; either to increase the aliment, or diminish the vegetation; the first may be done by plentiful watering, the other by diminishing the intensity of the light.

Excess of heat dries up the juices; if you attempt to remedy this by plentiful watering, the plant sprouts leaves, but very little fruit.

Caroline. This sort of vegetation must be well adapted to meadows, where a produce of leaves is principally aimed at.

1592.—Of party colored leaves, what is said—from what do they arise? 1593.—Of the second class of diseases what is said? 1594.—How does excess of light affect plants? 1595.—What are the modes of remedying this disease? 1596.—If there is an excess of heat, what is said?

Mrs. B. True; but plentiful irrigation is not always attainable: where it can be had, no evil effects need be apprehended from the sun.

A deficiency of heat produces dropsy, and often rotting: the most delicate parts of the plant first begin to decay, such as the articulations of the branches and of the leaf-stalks; hence the leaves and young branches fall off. A plant evaporates much more water than it retains; it may be compared to a tube into which you introduce water: now, it is evident, that the more you pour in at one end, the more must be poured out at the other: the evaporation by the leaves must correspond with the absorption by the roots, else the plant will suffer.

Plants are also often injured by exposure to external moisture. Rain is more hurtful to the wood than to the bark; the latter is a sort of great coat, provided by Nature to shelter the wood from the inclemencies of the weather: she has stored it with carbon, to enable it to resist putrefaction; and with siliceous earth, to render it firm and durable: but if, as it sometimes happens, the great coat be rent and ragged, the rains penetrates into the wood (which is very differently organised,) and having no means of escaping, the stem becomes rotten.

Emily. Among the injuries plants sustain from rain, we must not forget that of its making the pollen of flowers burst before it is mature, and hence preventing the seed from being brought to perfection.

Mrs. B. True; but we have already entered sufficiently into detail on that subject.

In regard to the influence of the air, I have formerly observed, that the agitation which the wind gives to plants is advantageous if not carried to excess: the cambium, being a thick viscous juice, requires motion to promote its descent.

Caroline. Yet you have said that the great aim of the gardener is to retard the descent of the cambium, in order that, by remaining longer stationary in the branches, it may afford more nourishment to the fruit.

Mrs. B. That is true, if the production of fruit be the

1597.—How is the result, if there is a deficiency of heat? **1598.**—What illustration is made with a tube of the absorption and evaporation with plants? **1599.**—What is said of the injury to plants from rain? **1600.**—How does the air affect plants?

object aimed at; but if, on the contrary, it be timber, we must promote the descent of the cambium into the trunk, instead of endeavoring to detain it in the branches.

Gentle exercise is, however, generally advantageous in the vegetable economy, and promotes the circulation of the juices: while violent motion occasions either exhaustion or fever. Hence the objection to props and espaliers; which we have already noticed. Boisterous winds are also mechanically injurious to trees, rending their branches, and sometimes tearing up their roots from the soil.

Plants are affected by the nature of the atmosphere in which they grow. There is nothing more prejudicial to them than smoke.

Emily. I am surprised at that; for smoke, you have told us, consists of small particles of carbon which have escaped combustion; and carbon, you know, is the favorite food of plants.

Mrs. B. The particles of smoke, though apparently so small to our senses as scarcely to be distinguished when separate, are mountains compared to the very minute subdivision which matter must undergo, in order to enter into the vegetable system. Smoke may clog the pores of plants, but can never gain admittance through them.

Emily. But smoke is always accompanied by a current of hot air, which must be strongly impregnated with carbonic acid; and in this state the carbon is so minutely subdivided as to be quite invisible, and, I suppose, sufficiently so to enter the pores of plants.

Mrs. B. If plants absorb carbonic acid by their leaves, or any part exposed to the air, it can be but in very small quantities. Under common circumstances, it enters into their system, only by their roots; it is their leaves which decompose it. Carbonic acid gas is as prejudicial to plants externally as it is to animals; for plants, under a receiver containing carbonic acid, die in the course of a few hours. Azote and hydrogen do not appear to be injurious to plants, unless in such quantity as to diminish the proportion of oxygen in the atmosphere, which their vegetation requires.

1601.—How is the production of fruit or of timber affected by the cambium? 1602.—What is said of gentle exercise? 1603.—And of boisterous winds? 1604.—How does smoke affect plants? 1605.—Why is it not beneficial, as carbon is a favorite food of vegetables? 1606.—Why is not the carbonic acid in smoke favorable to vegetation? 1607 —What is azote and hydrogen?

Third class of diseases arises from contusions or other external injury.

The accidental loss of their leaves, from whatever cause it may proceed, must be considered as a disease of plants: if it is not the effect, it is the cause of one; for when the sap rises to the branches, and finds no organs to elaborate its juices, it descends almost in the same state in which it rose, a thin crude fluid, little adapted to the nourishment of the stem and branches. Under these circumstances, its only resource is to feed and develope young shoots, which Nature intended should sprout only the following year. The sap is then elaborated in the leaves of the new shoot, is converted into cambium, and the regular circulation is restored.

Emily. How wonderfully prolific Nature is in resources to remedy any accidental interruption to her regular progress! One would almost imagine the sap to be endowed with a sort of instinct, when we find that it is no sooner disappointed in meeting with those organs requisite to its perfection, than abandoning its natural course, it busies itself in feeding and prematurely forcing into vegetation the organs which are deficient.

Mrs. B. This admirable fund of resources springs from an origin far superior to instinct. Its immediate cause is, it is true, probably either mechanical or chemical. The sap, for instance, cannot deposit the various juices required by the different organs, when a deficiency of leaves prevents these juices from being secreted. In its immature state it is, in all probability, better able to supply the elements required for the vegetation of buds; and thus the young shoots are prematurely forced into life. The mere mechanical philosopher will rest satisfied with this explanation; but if to the reflecting mind be added a feeling heart, he will discover that the beneficent Author of nature has so admirably regulated the laws by which it is governed, that they frequently find in themselves means of supplying remedies and resources against accidental contingencies.

Caroline. This is, indeed, admirable. In a work of human mechanism, however ingeniously contrived or skillful-

1608.—And of the loss of leaves? 1609.—How is the regular circulation restored? 1610.—Emily almost thinks the sap is endowed with a sort of instinct—what is the reply of Mrs. B.? 1611.—What comparison is made between the mechanical philosopher and the feeling heart in relation to this subject?

ly executed, constant attention must be paid to watch and remedy any accidental defect; whilst the laws of Nature are of so perfect a description that they are stored with those remedies which the mechanist is obliged to supply.

Mrs. B. The loss of bark is so serious an injury as often to prove fatal to plants. If the evil prevail entirely around the stem, so as to effect a complete solution of continuity, the cambium can no longer descend, and the plant must inevitably perish.

Caroline. But do you forget, Mrs. B., that in cutting a ring in the bark, to improve the fruit, you perform the very operation you say is so dangerous?

Mrs. B. The ring, you must recollect, is so narrow, that the swelling of the upper edge, from the accumulation of sap, soon produces a re-union of the several parts: but I was alluding to the destruction of the bark to so great an extent as to preclude all chance of such a remedy. If the bark be only rent on one side of the stem or branch, it may be considered as a partial infirmity, of which the plant may recover. For this purpose, the diseased part should be carefully cut away, and the wound be covered with an ointment. Let us suppose the rent to be of a long oval form, as is generally the case; the cambium, when it reaches this spot, meeting with obstruction, will accumulate, and produce a swelling on the upper edge of the wounded part: this will gradually descend on each edge of the severed bark, till it meets at the bottom, and the swelling will increase, till the two sides unite, when the wound will be healed.

Emily. I have often observed the swelling of the bark where a branch has been lopped; but it remains a protuberant ring around the wound, and does not close, so that the central part of the wood remains exposed.

Mrs. B. In this instance, not only no ointment has been used to shelter the part affected, but the wound being of a circular form, it is more difficult for the edges of the bark to meet. The young wood, however, which it is the most essential to shelter, is covered by the swol-

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1612.—What comparison does Caroline make between the laws of nature and human mechanism? **1613.**—What does Mrs. B. say of the loss of bark? **1614.**—Caroline thinks Mrs. B. has fallen into an inconsistency, as to the making a ring in the bark—How is this explained? **1615.**—If the rent be made in a long oval form what will be the result?

len ring of bark. The flagellations which trees sometimes undergo to bring down the fruit are injurious to them, by wounding the young branches; it is so also to the fruit, unless these be of the nut kind: for apples, pears, and olives, when thus brought down, are bruised and very liable to rot.

Plants often suffer from improper pruning. When a tree is lopped of its branches, they should be cut off obliquely; the sap, when it rises to the wounded part, will then flow down its slanting surface, while, if the amputation be made horizontally, not only will the sap be less able to run off, but the wound will be more exposed to the rain and wind, and putrefaction will probably ensue.

Emily. I have seen the trunks of old willows, the branches of which are lopped every year, become perfectly hollow; which arises, no doubt, from the wood being thus injured.

Mrs. B. This operation, which is called pollarding a tree, is done with a view of turning the branches to the greatest advantage: in willows, generally, for basket-work; in other trees, for fuel. When a tree is in the full vigor of life, it will be able to resist such merciless amputation; but when it becomes aged the wood will not support it without decaying.

Slight contusions, instead of being prejudicial to plants, produce an excitement which accelerates vegetation. The prick or perforation of insects, which we have noticed in the fig-tree, simply occasions a small swelling somewhat analagous to that produced by a blow given to an animal: in this swelling a minute quantity of sap is deposited, which nourishes more abundantly, and, consequently, developes more rapidly, the surrounding parts.

This leads us to the class of diseases arising from the action of animals on plants. But it is too late to enter upon it to-day: we shall reserve it for our next interview.

1616.—What is said of the flagellations which trees sometimes undergo to bring down the fruit? 1617.—When a tree is lopped of its branches, how should they be cut? 1618.—Why should they be cut obliquely? 1619.—What is called pollarding a tree, and what is said of it? 1620.—What is said of slight contusions upon the bark of trees?

CONVERSATION XXVII.

THE DISEASES OF PLANTS CONTINUED.

Mrs. B. Plants suffer much from their leaves being devoured, either by quadrupeds or insects. The former not only wound the branches in obtaining the leaves, but, if the soil be of a loose nature, they disturb the young roots; hence pasturage is esteemed injurious in loose and wet soils. But the insect tribe is a far more insidious and fatal enemy. Insects not only perforate the plant, in order to deposit their eggs, but, when these eggs are hatched, the larvæ or grubs prey upon the plants which have afforded them shelter, devouring their leaves, and often rotting the wood by their acrid juices. Most of these insects bear the name of *Cynips:* that which produces the swollen excrescence called gall-nuts, from which ink is made, is one of the most remarkable. The smoke of tobacco and washes made of infusions of that plant are the best preservatives against these minute but inveterate enemies. The insect called Cochineal fastens itself to the bark of trees, and sucks the juice through it. The black spots on orange-trees are insects of this class: they are generally pernicious in green-houses, and should be brushed off.

Caroline. I thought that cochineal was of a bright red color, and that the insect was peculiar to hot climates.

Mrs. B. The species you refer to comes from Mexico, and feeds on the *Cactus Opuntia*, from which it derives the name of cochineal; but there are many other species of this insect, which are not confined to tropical climates.

The fifth class of diseases results from the action of plants on each other. Plants being destined by Nature to produce a much greater quantity of seed than they can possibly bring to maturity, we may consider them as constantly struggling with their neighbors to obtain nourishment for their numerous offspring: thus they impoverish each other, and check that vigor of vegetation, which would take place, had every plant sufficient space and food not to interfere with the wants of its neighbors.

1621.—How do insects injure plants? 1622.—What are these insects called, and what one is the most remarkable? 1623.—What is the best preservative against them? 1624.—Of the Cochineal what is said? 1625.—From what does the fifth class of diseases result? 1626.—How is this explained?

Emily. That is very evident in the superior vegetation of a single tree, which has ample space for its branches, and food for its roots, to that of a tree in a crowded forest, where every inch of ground is disputed by surrounding plants.

Mrs. B. But, independently of this general competition for food, there are various other modes by which some classes of plants are noxious to others. Among these the parasitical plants stand pre-eminent. There are two classes of this description, distinguished by the epithets of *false* and *true*. The false parasite fixes itself to the plant, without feeding on its juices; while the true parasite feeds on the plant to which it adheres. These two classes are each subdivided into external and internal parasites, denoting the parts of the plant which they attack.

The false parasites consist of mosses, lichens, and fungi, which grow on living plants just as they would grow on a rock or a dead tree.

Emily. Such as the various mosses which grow on the stems of fruit-trees. But, if they do not feed on the tree, whence do they derive their nourishment?

Mrs. B. From the moisture of the atmosphere, and, possibly, from the relics of some preceding mosses, which supply a few particles of vegetable mould.

Caroline. If they do not feed on the juices of the tree, in what manner do they injure it?

Mrs. B. Chiefly by attracting moisture to the stem, and thereby endangering the wood; and also by affording a lodgment for insects. In these temperate climates, however, the harm they do is not of a very serious nature; but, in tropical regions, parasitical plants grow with such luxuriance (the vanilla, for instance,) that the tree suffers mechanically from the weight of the mass it has to bear.

Emily. I recollect, in the Caschines of Florence, seeing many of the elm-trees so completely covered with ivy, that I at first sight concluded the tree itself was of that description.

Mrs. B. Ivy is a creeping plant, not a parasite. Its

1627.—What is the difference between false and true parasites? 1628.—Into what other classes are parasites divided? 1629.—Of what do false parasites consist? 1630.—From what do they derive nourishment, if not from the tree on which they grow? 1631.—If they do not feed on the tree, how do they injure it? 1632.—How do trees suffer from parasites in tropical regions?

roots are planted in, and feed on, the soil: all it requires of the tree which it embraces, is support. Yet these plants, as you observe, are frequently prejudicial. I have seen trees whose branches have been so enveloped, and strangled, as it were, with creepers, that scarcely any room was left for its own proper foliage; and the growth of the tree was consideraly impeded.

But to return to our parasites. The Rhizomorpha is a false internal parasite, which attacks wood; and, though it does not feed upon its juices, the mere growth of the plant proves fatal to it, disorganising its parts, and reducing the wood to a sort of vegetable mould. This malady seldom occurs but in very aged trees.

Emily. We, artificial beings, whose aim is to have plenty of sound timber for building, consider this as a dreadful malady; but, in the course of nature, it may, perhaps, simply be a means employed to reduce old or dead trees, to the state in which they are fitted to return again into the vegetable system, for this mould must afford rich food for other vegetables.

Mrs. B. In natural forests, where the hand of man does not interfere to turn the timber to his own account, it is certainly desirable that Nature should devise some means of hastening the decomposition of wood, a substance so hard and compact that it would require a great length of time to effect it by the usual process of decay. In this operation, the Rhizomorpha is aided by a tribe of insects, which take up their abode in the cracks and crevices, it has made in the wood.

Caroline. The Misletoe is, I suppose, a true parasite; for it derives its nourishment from the tree to which it is attached.

Mrs. B. The seed of the misletoe fastens itself to the tree by means of a glutinous substance with which it is covered. The radicle of this seed shoots out in a manner different from that of any other plant: being too feeble, on its first entrance into life, to penetrate so hard a soil as wood, it shoots out in some other direction.

1633.—What is ivy and how does it injure trees? 1634.—What is said of the Rhizomorpha? 1635.—How does Emily think it may be serviceable in natural forests? 1636.—How is the Rhizomorpha aided in producing the decomposition? 1637.—How is the seed of the misletoe fastened to the tree, and what is said of its germination?

Caroline. It grows, then, in the light and air, which must be an equally uncongenial soil!

Mrs. B. True; and it no sooner makes this discovery, than it changes its course, and, curving round, retraces its steps towards the branch whence it sprouted.

Caroline. Just as if it were conscious that the soil it had abandoned, was that in which it was destined to grow.

Mrs. B. It is said that it is in order to avoid the light, that it alters its course; for roots, you know, dread the light as much as leaves and branches delight in it.

Emily. The dread of the former may, no doubt, be as mechanically explained as the delight of the latter.

Mrs. B. Certainly. The extremity of the root having now acquired sufficient strength, as soon as it comes in contact with the branch, pierces the bark, and plants itself in the alburnum, whence it sucks up its food, just as another plant would do from the soil.

Caroline. With the advantage that its food is already prepared; it can therefore scarcely require leaves to convert the sap into cambium.

Mrs. B. I beg your pardon. The soil from which it feeds is the wood, not the bark; it is therefore the rising, not the descending sap which it receives; the misletoe, and the tree to which it adheres, may therefore be considered as the same individual plant. The parasite receives the sap after the same manner as the branches of the tree, and like them, requires leaves for its elaboration.

Emily. This junction is very analogous to a natural graft.

Mrs. B. On the contrary, it is quite the reverse. In a graft, it is the vessels of the liber which unite; whilst the misletoe strikes its little root through the bark into the wood, and the junction of the vessels takes place in the alburnum.

Emily. Is it not wonderful that so young and tender a root should be able not only to pierce the bark, but even to penetrate the wood?

Mrs. B. It is, indeed; but observe that it does not

1638.—What takes place, when the light and air are found prejudicial? **1639.**—How does the light effect the roots of plants? **1640.**—What takes place, when the extremity of the roots have acquired sufficient strength? **1641.**—Why does Caroline suppose it does not need leaves? **1642.**—How does Mrs. B. show that she is mistaken in this particular? **1643.**—Why may not the misletoe be viewed as a graft upon the tree?

go deeper into the wood than the external layer, which being the last formed, is the most tender.

Emily. Then it cannot be so difficult to root out a misletoe, as I have heard?

Mrs. B. You must recollect, that every year a new layer of wood grows over the root; so that without having, itself, penetrated further, it becomes annually buried deeper; and after some year's growth in so hard and compact a soil, that there is but little chance of being able to extract it, without wounding the branch beyond recovery; the only mode of effectually extirpating it, is to cut off the branch to which it is suspended; it is better to lose that, than to suffer the tree to be molested by so disagreeable a companion.

The misletoe is more partial to some species of trees than to others; but the oak is the only one almost wholly exempt from its depredations.

Caroline. I thought that the misletoe attached itself to the oak in preference to all other trees, and that the Druids considered their union as sacred.

Mrs. B. It was probably owing to its so seldom attacking this tree, that the Druids held it in such high veneration when they found it there. This tree has, however, another enemy, of a very similar description, called the *Laurientius*, which confines its ravages to this sovereign of the forest.

The *Cuscuta*, commonly called *Dodder*, is a parasite, which attacks lucerne, trefoil, and several of the artificial grasses: it has neither cotyledons nor leaves, consisting simply of a sort of filament or stalk, which, after it has sprouted, falls and perishes, when it finds no plant to which it can adhere; but if it meets with any of the artificial grasses, it fastens upon them, and feeds upon their juices. The seeds sometimes germinate in the soil, and sometimes on the artificial grass itself. The mode of destroying this noxious parasite, is either to burn or to mow the artificial grass very frequently, in order to prevent the seed of the Cuscuta from germinating; or else to change the course of cropping, and sow corn, for this parasite will not attack grain, or any endogenous plant. There

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1644.—How deep does the root penetrate? **1645.**—Why is it not easy to root out a misletoe? **1646.**—Is the misletoe common to all trees? **1647.**—If it is not partial to the oak, why were the Druids disposed to consider an union of them sacred? **1648.**—What is said of the Cuscuta? **1649.**—How does it germinate and how may it be destroyed?

are three species of Cuscuta, one of which attaches itself exclusively to the vine: its filaments are as large as a small packthread; fortunately, this last is very rare.

The *Orobanche* is a genus, one species of which adheres to the roots of hemp, and destroys them by devouring their juices.

Fungi form a very considerable class of false parasitical plants; to this class belongs the *Erisiphe*, which attacks the leaves of plants: it first makes its appearance under the form of yellow spots, which afterwards turn black. There are no less than forty different species of this parasite.

The Rhizoctonia is a species of fungus, which confines itself almost wholly to the roots of lucerne and saffron: this disease manifests itself by the fading of the head of the plant, and the contagion soon spreads around it, in rays as from a centre. If one of the affected plants be pulled up, the roots will be found covered with the noxious filaments of this fungus: their effects on saffron is so baneful, that the malady it produces bears the name of *death;* and the only way to prevent its spreading, is to bury the affected plants in a sort of cemetery, for it is necessary to surround them by a ditch; and in digging it, care must be taken to throw the earth inwards, to prevent the contagion from spreading. There are three species of this destructive fungus, the brown, the carmine, and the white: the latter attacks fruit trees; its filaments are free from tubercles, while those of the former are covered with them.

The class of internal fungi is very numerous, there being not less than three hundred species, each attaching itself to the plant which suits it. Some of them attack all the plants of the same family; others confine themselves to those of the same species. Two of those species of fungi belong to the rose-tree: they appear at first under the form of small yellow spots; these increase till they run into each other; their color then changes to various tints of brown and red, tints which you must have observed the leaves of the rose-tree often assume, long before their natural decay.

1650.—What are the three species of it? 1651.—What is said of the Orobanche? 1652.—What is said of the Erisiphe? 1653.—And of the Rhizoctonia? If one of the plants affected by it be pulled up, how will the roots appear? 1654.—What are the three species of this fungus? 1655.—What is said of the class of internal fungi? 1656.—And of the two species which belong to the rose tree?

Caroline. This malady, far from disfiguring the plant, adds to its beauty; but who would ever have imagined these colors to have proceeded from a separate vegetation growing on the leaf?

Mrs. B. *Smut* is a fungus, under the form of a black powder, which lodges itself on the surface of the ears of corn, particularly of oats. But the most insidious enemy of grain, of the mushroom tribe, is called the Rot. It devours the seed, without making its appearance externally. When the corn is thrashed, the rotten seeds burst, and the disease is thus communicated to the rest of the corn; so that if sown, the rot will be propagated as well as the corn; to prevent which, corn that is at all affected with this disease should be soaked in a lime wash, which destroys the seed of the rot, without injuring that of the corn.

Mr. Benedict Prevost has found that washes of vitriol or verdigris, are still more efficacious.

Emily. But are they not pernicious to the grain, and even dangerous to those who employ them?

Mrs. B. It was at first apprehended to be so, but it is now well ascertained, that neither the laborer nor the grain suffer from this process: it is much used in France, and even arsenic has been tried with success for this purpose.

The Ergot is a disease peculiar to rye, which attacks the ovary of that plant; and bread made of rye thus affected is extremely unwholesome, frequently producing gangrene.

It would be endless to detail the various fungi which molest the vegetable kingdom; we will conclude, therefore, with the *Rust*, which confines its depredations to the grasses.

It is time now to turn our attention to the last class of diseases, those resulting from age; and here you must observe that a very essential difference exists between the animal and the vegetable creation. In the former, all the organs are developed at once: these after long use become indurated, obstructions take place, decay follows, and life thus often terminates from old age. But the economy of the vegetable kingdom is totally different: the organs of

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1657.—What is said of the smut? 1658.—And of the rot and its effects? 1659.—How may it be prevented? 1660.—Are not these antidotes injurious to the corn and to the persons who use them? 1661.—What is said of the Ergot, and the Rust? 1662.—So far as disease results from age what comparison is made between animals and vegetables?

the plant, that is to say, the vessels which convey the juices, the leaves which elaborate them, the buds which produce flowers and fruit, are renewed every year; they are always fresh, always young: how then can a plant decay from age?

Caroline. I should rather ask why all plants do not, like annuals, die every year? for these organs which are renewed in the spring, perish in the autumn.

Mrs. B. Of all the organs which are annually renewed in perennial plants, the layer of wood and of bark alone survive in an active state of vegetation: the others may be considered as annuals, living but one season.

Caroline. Then, when a tree dies of age, it is from the stem being worn out: every year the wood hardens by the pressure of the new layers which grow around it: its vessels must, in consequence, become obstructed, and less adapted to convey the fluids which are to pass through them: this bears a strong analogy to the decay and death of animals.

Mrs. B. True; but observe that if these vessels are no longer calculated to transmit the juices, the plant no longer requires them to execute this function: it is performed by the fresh layer of wood and of bark which are renewed every year: the old repose after their labors, but do not perish; age, therefore, does not necessarily entail death, as in the animal kingdom.

Emily. From what cause, then, do plants die? for, though some trees live to a great age, they all ultimately perish, as well as animals.

Mrs. B. They are certainly not destined to immortality; but their ceasing to exist seems to depend upon some accidental disease proving fatal, rather than upon any prescribed term of years assigned to them by Nature.

The malady which most commonly destroys plants is exhaustion, arising from their bearing, and ripening, too great a number of seeds: it is this which regularly, though not necessarily, occasions the death of annuals; for, if from any accidental circumstance the seeds are not matured, the plant retains sufficient vigor to live through another season.

1663.—Caroline asks, why all plants do not die every year—What is the answer? **1664.**—What does Caroline suppose when a tree dies from age? **1665.**—What additional remarks does Mrs. B. make upon what Caroline says? **1666.**—Emily asks—From what cause plants do die—What is the answer of Mrs. B.? **1667.**—With what malady do they most commonly die?

Perennials, which live several years, perish ultimately of the same disease.

Caroline. And are there no means of diminishing the number of seeds of annuals, and by thus preventing exhaustion, of transforming them into perennials?

Mrs. B. This may be done by making the flower grow double: the additional number of petals are produced at the expense of the seed; but requiring much less nourishment, the plant is not exhausted.

Emily. But, if trees perish only by accidental death, some, at least, should escape; for accidents do not always occur.

Mrs. B. Not, perhaps, to a certainty in any given period; but in the long course of time, they never fail to happen; and the extreme inequality in the length of life, in trees of the same species, affords ground for believing that its duration depends upon accident.

Emily. But some kinds of trees are regularly much longer-lived than others: the oak, for instance, than the poplar; forest, than fruit-trees.

Mrs. B. Some plants are naturally much more robust than others, and therefore resist during a longer period accidental attacks. The oak, so vigorous and magnificent a tree; out of six seeds which it produces in every blossom, brings only one to maturity; and yet with how much less effort could the oak ripen clusters of acorns than an orchard tree the heavy load of fruit, under the weight of which its branches bend; and if any of them break, how great is the probability that decay will ensue: the enfeebled vessels of the wood, exhausted by the labor of conveying sap to so much fruit, are unable to resist the consequences of exposure to the weather; and, after a series of accidents of a similar nature during a course of years, the tree at last perishes. When, therefore, it is said that such a species of tree, usually lives such a number of years, the duration refers to the average of time in which it falls a sacrifice to accident. This average it is very difficult to ascertain.

1668.—How may the number of seeds in annuals be diminished? **1669.**—Why may not some trees live always, if they have only an accidental death? **1670.**—What is said of the seeds of the oak—its age, &c.? **1671.**—And of fruit trees? **1672.**—When it is said that certain species of trees live so many years, what is to be understood?

But it is not only ripening seed, which eventually exhausts plants; all the various diseases we have enumerated tend to shorten their existence.

Emily. Yet those only which attack the wood or bark can prove dangerous to the life of the tree: injury to the other organs, can be of little consequence, since they naturally perish in the autumn.

Mrs. B. True; but observe that most of the diseases we have mentioned are of that nature; the parasites suck up the juices of the stem; the fungi which adhere to the stem and branches, those which coil round and strangle the roots, all eventually injure the wood.

There is in the island of Teneriffe a tree, the Dracæna Draco, of so remarkable a size, that it served to point out the limits of possession of different tribes when the island was first discovered: it has since been repeatedly visited by different travellers, and during several centuries past appears to remain unchanged: it may possibly be of so vigorous a nature as to have existed some thousand years.

Caroline. And the extraordinary large tree in the Cape Verde islands, Mrs. B., in which Mr. Adamson discovered an inscription buried under three hundred layers of wood, must have been of a very great age.

Mrs. B. From its dimensions and appearance, he calculated that it was probably about five thousand years old.

Caroline. Even allowing for an error of a thousand years or two in his calculation, the tree would still be of a very venerable age.

And, without going so far for an example, in Blenheim Park there are still in existence old trunks of trees, which are said to have shaded the retreat of the fair Rosamond: and they are supposed to be now not less than a thousand years of age.

CONVERSATION XXVIII.

ON THE CULTIVATION OF TREES.

Mrs. B. Nature has divided the surface of the earth into meadows and forests: in some parts of the globe, these

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1673.—What besides ripening the seed exhausts the plant? 1674.—Emily thinks the diseases enumerated might not be of essential injury to trees, except those which attack the wood or bark—What is the reply to her? 1675.—What is said of a tree of remarkable size in the island of Teneriffe? 1676.—And of one of the Cape Verde islands? 1677.—And of those in Blenheim Park?

are so happily blended as to form the most beautiful variety of prospect; but in general, where the hand of man has not interfered, they are divided into immense masses of wood and pasture, which render the appearance of the country monotonous and melancholy.

Emily. I should have thought that, in the course of a series of years, these different species of vegetation would have intermixed, so that the seeds of the forest trees would have sown themselves and grown up amongst the grass, while the latter, on the other hand, would have spread amongst the trees and gained ground upon the forest.

Mrs. B. On the contrary, these two species of vegetation reciprocally interfere with each other, so as to prevent either from encroaching on their established limits; for grass will not grow under the impenetrable shade of a forest, nor will the seeds of trees germinate in those thick and rich wild pastures called Steppes, where the grass rises to six or eight feet in height.

In tropical climates, forests are composed of a much greater diversity of trees than they are in our less genial latitudes; and the more you travel northward, or the greater the elevation of the land, the more homogenous the woods become.

Caroline, I have observed this, both in travelling in Scotland and in ascending the mountains of Switzerland. The walnut, the oak, and the birch successively disappear, and the summits are almost always crowned with firs.

Mrs. B. It is remarkable, that under the same latitude, America can boast a much greater variety of trees than Europe: we possess but thirty-four species, while she has no less than one hundred and twenty. It is to be hoped, at least, that we shall be able to increase our stock from so well furnished a market.

Emily. America being a more recently settled country, and less populous, can afford to raise wood in a better soil, whilst we, in Europe, are so restricted for space, that all our good soil is set apart for grain, and we plant wood only where nothing more valuable will grow.

1678.—How is the surface of the earth? 1679.—In a course of years what does Emily suppose might have taken place? 1680.—Why is not this the case? 1681.—Of forests what is said in tropical climates; also in more northern regions? 1682.—What is said of the variety of trees in Europe and in America—how many species of trees in each?

Mrs. B. That is necessarily the case in all highly civilised and thickly populated countries; corn being a more valuable produce than timber, will obtain the preference where the soil is adapted to it.

Our natural forests, in such land as we allow them to occupy, consist of little more than the oak, the ash, the beech, the birch, and, in elevated situations, the fir.

Forests are divided by botanists into tolerant and intolerant: the former admits of trees of another species growing amongst them; the latter exclude all but their own.

A forest of oaks is of the former description; underwood of various descriptions growing beneath it; whilst beeches and firs do not allow this privilege to the inferior plants, and are hence denominated intolerant.

The thirty-four species of European forest-trees are divided into four classes.

1st Class. Trees with hard wood: this class comprises three species of oak.

Long-stalked oak.	Chesnut.	Hornbeam.
Stalkless oak.	Elm.	Pear.
Tauzin oak.	Ash.	Apple.
	Sycamore.	

2d Class. Trees with soft wood.

Lime.	Poplar.	Willow.

3d Class. Trees with resinous wood.

Pine.	Fir.	Larch.

4th Class. Evergreens, not resinous,

The Evergreen Oak, of the south of Europe.

There are two modes of felling forests; which the French call *en Jardinier*, or *Taille regle*, and for which we have no equivalent terms in English. In the former, you successively cut down the large trees as they grow up to the size of timber; in the latter, the whole of the forest is felled at once.

1683.—Between highly civilized and thinly populated countries, what difference will there necessarily be? 1684.—Of what do English forests consist? 1685.—What is understood by tolerant and intolerant when applied to forests? 1686.—What is said of oak, beech, and fir in relation to this division? 1687.—Into how many classes are European forests divided? 1688.—What ones does the first class include? The second? The third? The fourth? 1689.—What are the two modes of felling trees?

Caroline. The former must surely be the best mode; for it seems mere waste to cut down the young trees before they are large enough to be of use.

Mrs. B. It is difficult to fell the large trees without injuring the small ones. They are deprived of the shade and shelter of the large trees, and their roots are often deranged and their branches broken by the fall of their protectors. When forests are felled completely, it is done at regular periods, which are determined either by the nature of the wood or the purpose for which it is intended. For the ordinary consumption of fuel, it is usually cut down every twenty years. When the trees have attained a sufficient size for fire-wood, and in countries where wood is the only fuel, this is the principal object in view. This is generally the case in most parts of the world. Our island, where coal is so commonly burnt, forms an exception. We devote much less time to planting, because we derive our fuel from the bowels, rather than from the surface, of the earth; and our woods are raised chiefly to produce timber for building: but the *taille regle* is generally adopted on the Continent. It admits, however, of some modification: instead of cutting down the large trees, and leaving the young ones to grow up, the young trees are cut down generally about the age of twenty years; with the exception of the finest plants, which are reserved for the next periodical felling. These trees are called standards or standers. The young trees are cut up into faggots for burning, and into props to support vines: their stumps quickly send forth new shoots, which at the end of another twenty years are fit to be cut down for the same purpose. The greater number of the standards are then felled, having acquired dimensions which enable them to be cut into logs for fire-wood. The standards which escape the second felling, in France, assume the name of *sur taillis:* if reserved a third time, they are called *sur ecorce;* and should they be so fortunate as to survive the fourth felling, they become timber.

Emily. I really quite tremble for the reserved trees

1690.—What is said of the former method? **1691.**—And of the latter? **1692.**—Why do the English pay but little attention to the planting of trees for fuel? **1693.**—When, on the continent, are the younger trees cut down? **1694.**—What are called standers? **1695.**—By what names are trees called in France if they escape the second and third felling?

every time the wood-cutter enters the forests; it is well they are not endowed with a consciousness of the risk they run. And at what age are timber-trees felled?

Mrs. B. Their length of life will be more likely to excite your envy than your compassion. Oaks and beeches are not considered as ripe for timber, until they have attained the age of 120 or 130 years. After that period, there is a greater chance of their deteriorating, than of their improving.

Caroline. Wood for burning, then, cut down in the successive fellings is from twenty to nearly fifty years of age?

Mrs. B. Beech, when not reserved for timber, is not suffered to live beyond thirty years; because, after that age, young shoots will no longer sprout from the old stumps.

Resinous trees do not shoot out afresh after felling; woods of firs must therefore be cut down altogether, and resown; or the forest may be felled in alternate stripes, which is attended with this advantage, that the stripes left growing shelter the young plants which shoot in those that have been felled. When the firs are situated on the declivity of a mountain, as it very frequently happens, the wood-cutters must begin their operations from below, in order to be able to carry away the trees with greater facility

The proper season for felling forests, is from the middle of November to the middle of April; and the instrument best adapted for that purpose is a sharp axe, which should be used as near the ground as possible; the buds of the old stumps shooting much more readily when an axe is used than a saw.

Emily. And pray what species of trees do you consider as making the best fuel?

Mrs. B. That which is heaviest: the weight indicates the quantity of carbon it contains; and you may recollect that, in the combustion of wood, it is the carbon which gives out most heat.

Caroline. Yet I should prefer the wood which produces most flame. Flame is so cheerful, that it appears, perhaps, to give out more heat than it really does.

1696.—At what age are oak and beech ripe for timber? 1697.—At what age is beech to be cut for fuel, and why? 1698.—What is said of the felling of fir trees? 1699.—And situated on the declivity of a mountain? 1700.—What is the proper season of the year for felling forests? 1701.—What species of trees is best for fuel?

Mrs. B. The light which accompanies it, in a great measure, atones for its deficiency of intensity; but flame must be considered as a species of luxury, in which those only can indulge who do not aim at economy in fuel. The greatest quantity of heat is given out when the wood burns red, without flame; consequently, the wood which has the fewest volatile parts producing flame, and the greatest quantity of carbon, producing red heat, is the most valuable for fuel. Here is a list of the various proportions of carbon contained in equal quantities of wood of different species:—

	Oz. of Carbon, the Cubic Foot.		Oz. of Carbon, the Cubic Foot.
Black fir . .	86	Beech . .	64
Red fir . . .	84	Pear . . .	54
Evergreen Oak .	69	Birch . .	—
Box . . .	68	Willow . .	27
Oak . . .	60	Poplar . .	—

I have already mentioned the danger incurred by stripping trees of their bark, in order to harden the wood, by forcing the cambium to descend through it. This mode is, however, sometimes attended with success, provided that it be performed only the spring previous to the trees being felled; and that the naked tree be charred or slightly burnt, as a substitute for the covering of which it has been deprived, and a preservative against the inclemency of the weather.

Caroline. That is to say, that the wood is burnt to save it from suffering from wet! I should really think, the remedy worse than the disease. In travelling in Italy, I recollect seeing such miserable flayed and blackened trees, looking as if they had been put to various species of torture before the executioner came with his axe to strike the final blow.

Emily. They reminded me rather of poor naked savages, smeared and tattooed as a substitute for their deficiency of clothing.

Mrs. B. Why should you not compare them to sheep

1702.—What is said of the burning of wood so as to produce the greatest quantity of heat? **1703.**—What is the comparative quantity of carbon contained in different kinds of wood? **1704.**—When is the stripping the bark from trees attended with success? **1705.**—What does Caroline say she has seen in Italy of this description? **1706.**—Of what does Emily say this reminds her?

shorn of their fleeces in the spring?—the bark of the tree is no less useful in the arts than the fleece of wool: you recollect that it contains the astringent principle called tannin, so essential in the preparation of leather: it is oak bark which is principally used for this purpose, as it contains the greatest quantity of tannin.

Let us now consider the cultivation of single trees.

Emily. Such as form the ornament of parks and pleasure grounds; and those which, dispersed throughout the country, produce such beautiful scenery in England.

Mrs. B. There is certainly no country which can boast such a natural, and picturesque arrangement of trees. On the Continent, single trees are generally planted in rows: in some districts they may be considered as a supplement to forests. Almost all the trees in Belgium, for instance, grow in hedge-rows, or in avenues on the side of high roads. What species of trees should you think best calculated for the latter purpose?

Caroline. Evergreens would not be suitable; at least in our northern climates, because the road requires exposure to the sun and wind during winter, and the passenger requires no shade in that season.

Emily. They should be trees which afford sufficient shade in the summer, but whose foliage is not so thick as to prevent the road from drying, after heavy showers.

Mrs. B. For this reason the horse-chesnut is not adapted to such a situation; for, though it would afford excellent shelter to passengers during a shower, it would render the road damp. Trees with very wide-spreading roots are also objectionable, as they encroach on the adjacent culture: on this account the acacia is excluded.

Emily. But in England the road is almost always separated from the contiguous fields by a ditch, so that the roots could not well interfere with their produce.

Mrs. B. The roads in England are seldom bordered with trees, except occasionally in hedge-rows: our climate being too damp to admit of such an ornament, while in the southern parts of the Continent trees are almost a

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1707.—What comparison does Mrs. B. make between this practice and the shearing of sheep? **1708.**—On the continent of Europe how are single trees planted? **1709.**—Why would not evergreens be suitable for this purpose? **1710.**—And horse-chesnut? **1711.**—And trees with wide spreading branches? **1712**—In England why are not roads bordered with trees?

necessary accompaniment to roads, on account of the shade they afford.

Caroline. I think fruit-trees, and such as have sweet-smelling blossoms, should be planted for the gratification of the passengers.

Mrs. B. I am afraid that the kindness of your intention would be frustrated; for as these trees are not the property of the public, it would be only leading the passenger into temptation, and exposing the tree to danger; the fruit would be unlawfully gathered, and eaten, in all probability, before it was ripe; and the tree would suffer from the pulling and breaking of its branches. When fruit-trees grow on the high road, the proprietors are often obliged to fence the stems with briars and brambles, to prevent their being climbed, and to lop the lower branches, in order that they may be above the reach of the passengers.

The elm is one of the trees best adapted for the high road: it may be transplanted without injury, after it has attained such a growth as to enable it to resist the attacks of cattle, an essential point for trees so much exposed: it is robust in its nature, of long duration, and affords a light and pleasant shade: its roots are superficial, and yet not spreading, and it bears neither flowers nor fruit which can tempt the passenger.

The plane, a tree very common on the Continent, is also well adapted to roads. It comes into leaf very late, so that the roads have full time to dry in spring. The oak is so robust and durable a tree, that it would be excellent for this purpose, could it be transplanted sufficiently large to preserve it from accidental injury; but it suffers from transplanting unless very young. The best mode of rearing oaks for avenues is to plant them in hedges: the bramble, or other shrubs of which the hedge is composed, afford them shelter and defence, until they are of an age to resist accidental injury; the hedge may then be cut down at pleasure. This has also the advantage of forcing the roots of the oak to descend: for the roots of the hedge, being more superficial, consume the nourishment near the surface of the soil, and compel those of the oak to seek it in a lower region.

1713.—Why are not fruit trees suitable to be planted on the sides of roads? 1714.—When they are so planted, what do the proprietors have to do? 1715.—What is said of the elm for this purpose? 1716.—Of the oak and plane? 1717.—Of the best mode of rearing the oak?

The birch is well calculated for roads, if the soil be sandy; it thrives in a cold climate and in elevated situations, and the lightness of its foliage is an additional advantage in such temperatures.

The sycamore is a beautiful tree for avenues. The horn-beam is objectionable only on account of the slownees of its growth. The aspen, the ash, and the poplar, are well adapted to a moist soil, as they help to drain it. An avenue of poplars is not picturesque, it is true, but it affords almost as much shelter from the wind as a wall, and in some situations this is very desirable.

Emily. A few poplars, interspersed with other trees, form, I think, beautiful groups; but an avenue of poplars is associated with the idea of marshy ground, and from its formality is extremely ugly.

Mrs. B. In planting trees by the road-side, the holes should be made both deep and wide; for the ground not being cultivated is hard and compact, and the young roots would be unable to penetrate it, were it not prepared and lightened by the pickaxe or the spade.

The young trees should never be headed or lopped; it thickens their foliage, but destroys the natural character of the tree. Some of their lateral branches may be slightly pruned; for as the branches in general correspond with the roots, the more erect the former grow, the more the roots will descend into the soil.

Caroline. The beauty of the greater part of the trees on the Continent, is spoiled by the merciless mode they have of heading them when young, in order to make them grow thick and bushy.

Mrs. B. In transplanting young trees, the more they are lopped, the more certainty there is of their living; and nurserymen who usually supply them, and warrant their taking root, make no scruple to amputate both head and branches.

Caroline. The life of the plant may be thus secured, but it no longer deserves the name of a tree; it is a stake,

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1718.—What is said of the birch for this use? 1719.—Of the sycamore, the hornbeam, the aspen, the ash, and the poplar? 1720.—In the planting trees by the side of the road why should the holes be deep and wide? 1721.—What is said of heading or lopping young trees? 1722.—What effect does this have on their living?

or a pole; which, though it may throw out branches, will never have the free, natural character of its species. Is it not, therefore, far preferable to run some trifling risk of losing them, rather than mutilate them in so barbarous a manner?

Mrs. B. I perfectly agree with you: besides, the risk is so trifling. In transplanting trees into the botanical garden at Geneva, the branches are never lopped, and only about five per cent die; yet the chance of their perishing must greatly exceed that of common transplantations, as the trees come from foreign climates, and are placed in a soil and temperature more or less unsuited to them; besides which, they have undergone the confinement of packing, and the fatigues of a long journey. It must, however, be acknowledged, that the art of packing and conveying plants is highly improved; for M. De Candolle frequently receives plants, not only in leaf, but in full blossom.

If, however, gardeners will persevere in this system of lopping, they should at least do it with moderation and judgment.

Emily. There is, however, some apology for nursery gardeners: the trees, in their grounds, are so thickly planted, that they cannot be taken up without injury to their own roots, or to those of their neighbors; and if the roots be cut, is it not necessary also to lop the branches, for mutilated roots can ill supply the whole of the branches with nourishment?

Mrs. B. Your observation is very just; but young trees, raised with a view to transplantation, should never be allowed to grow so thickly, as to interfere with each other; it is the duty of a nurseryman to transplant them in his own grounds, in order to give them space, if he has not a market for them elsewhere.

When a very large tree is to be transplanted, it is advisable to do it in the heart of winter, during a frost; a trench should be dug around, and, as far as attainable, below the stem of the tree, and be filled with water, if the rain does not sufficiently perform that office. When the water is frozen, the tree will be inclosed, as it were, in a

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1723.—What objection is there to this method of securing the life of trees? 1724.—What is said of transplanting trees in Geneva? 1725.—If trees are to be lopped, how should it be done? 1726.—How may the evil from nursery plants growing too near together, be remedied? 1727.—If a large tree is to be transplanted, when should it be done?

vase of ice, and may be taken up with the clod of earth attached to it; and, contained in the icy vase, it may then be conveyed to the place of its destination, almost without being sensible of its change of situation. This is, however, a very expensive operation, as it requires a considerable mechanical force to accomplish it: it can be done, also, only where the frost is severe and of long duration; for if the vase be melted or broken before the tree is placed in its new situation, the whole fails.

Sir Henry Stewart of Allanton has, within a few years, introduced a mode of transplanting large trees, which appears to have been attended with great success. It is precisely the reverse of that I have mentioned, yet founded on the same principle of guarding the roots from injury: with this view, instead of carefully covering up the roots, he lays them bare, but he separates the earth from them with such extreme precaution, that not even the smallest fibres are injured: this is done by laborers, whom he calls pickmen; because their business is to clear the roots from the earth by means of a small instrument adapted to the purpose, or with their fingers; a ball of earth is left close to the stem with the sward upon it. An engine is then brought up to the tree, consisting of a strong pole mounted upon two high wheels; the pole is strongly secured to the tree, while both are in a verticle position, they are then brought down to a horizontal one, by the pole acting as a lever; and by its descent, the few central roots, which the pickmen could not reach, are rent from the ground. The tree is so laid on the machine as to balance the roots against the branches, and one or two men are placed aloft among the branches of the tree, where they shift their places like movable ballast, as occasion may require. Both roots and branches are carefully tied up. The pit for receiving the tree, which should be prepared a twelvemonth before, is now opened, and the tree set in the earth as shallow as possible. The roots are then loosened from their bandages, and divided into the tiers, or ranks, in which they grow from the stem; the lowest of these tiers is then arranged, as nearly as possible, in the manner in which it lay originally, each root with its rootlets and fibres being imbedded in the soil with the

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1728.—How should it be done? 1729.—What objection is there to this mode of transplanting? 1730.—What mode of doing it has been adopted by Sir Henry Stewart?

utmost precaution, the earth being carefully worked in by the hand and the aid of a small rammer: additional earth is then gradually sifted in, and gently kneaded down, till it forms a layer, in which the second tier of roots is extended in the same manner as the lower tier, and so on till the whole are covered with earth. This attention to incorporate each fibre of the roots with the soil not only answers the purpose of inducing the roots to re-commence their function of absorbing sap, but also serves to fix and secure them firmly in the soil, and renders stakes, ropes, and other means of adventitious support unnecessary.

Caroline. And by your account this does not appear to be a very expensive process.

Mrs. B. No; independently of the engine, which is very simple, it is estimated that trees from twenty-six to thirty-five feet high, may be moved half a mile, at the expense of from ten to thirteen shillings. But the experiments have always been made with healthy trees, whose roots and branches have had ample space for growth; not tall emaciated plants torn from the interior of forests, with stinted roots and branches, and so little vigor of vegetation, that their bark would not be either of sufficient thickness or hardness, to shelter the stem from the rude blast, nor the roots of sufficient strength or extent, to fix it firmly in the soil. Sir Henry Stewart, therefore, particularly recommends transplanting trees which have been freely exposed to the advantages of light and air; and should they, by such exposure, have suffered in their growth on the weather side, he advises, in transplanting them, to reverse the aspect, in order to shelter the weak side of the tree, and expose the luxuriant one to the severity of the wind.

Emily. By this means, then, large trees may be transplanted without either cutting the roots or lopping the branches?

Mrs. B. By adopting all the precautions I have mentioned, it appears that scarcely a tree failed. Sir Henry is, no doubt, perfectly correct in not cutting, even the little tassels of rootlets which grow at the extremities of

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1731.—Is this an expensive mode of transplanting? **1732.**—How great is the expense? **1733.**—With what description of trees have these experiments always been made? **1734.**—What recommendation does Sir Henry Stewart give in relation to the transplanting of trees?

the roots, provided the operation of transplanting be performed with so much caution that these suffer no injury; but if the spongioles be crushed, or the fibres any way mutilated, it is better to amputate the extremities, which will shoot afresh, more quickly than the rootlets would recover of their wounds.

It is wrong to plant in wet weather; for, though watering is required after planting, the hole in which the tree is placed must not be filled with mud: it would greatly endanger the roots.

In such wet countries as Holland, they are often obliged to bury faggots beneath the soil intended for planting, in order to increase the filtration of the water.

From the cultivation of trees we shall proceed to that of hedges: these are destined either for shelter or defence. In former times there was a third description of hedges, designed for ornament; but our landscape-gardeners have entirely exploded the grotesque figures, cut out in box and yew, which excited the admiration of our forefathers.

That district in the west of France, called the Boccage, derives its name from the high and bushy hedges with which it abounds, and which are designed to afford shelter from the stormy winds of the Atlantic. There are but few trees in those parts; but the hedges, being from eight to ten feet in height, are sufficient to protect the crops from the boisterous sea-breezes, and they thence bear the name of *brise vent*.

Caroline. In England, our hedges are calculated more for defence; but the trees, with which they are interspersed, serve also the purpose of shelter.

Mrs. B. Our climate is unfortunately so damp, that exposure to the sun and air is rather an advantage than otherwise.

Hedges for defence answer the double purpose, of enclosing cattle in their pastures, and excluding those which might trespass on it.

Emily. Does it not also afford security against thieves?

1735.—What is said of cutting the roots of trees when transplanted? 1736.—And of the weather when it is done? 1737.—What are they obliged to do in Holland? 1738.—For what purposes are hedges designed? 1739.—What is said of the hedges in the west of France? 1740.—What is the double purpose for which hedges of defence will answer?

Mrs. B. It has been so considered, but, I am inclined to think, erroneously. A thief may lie concealed, and lead away a sheep or a cow at night, under cover of a hedge, without being discovered; whilst there is scarcely any night so dark, that he might not be perceived on an open plain.

It is objected to hedges, that they occasion a waste of ground: when necessary, therefore, they should be made to occupy as little space as possible, and be thickened, by crossing and engrafting the branches on each other, rather than by planting a double row. An external ditch is liable to the same objection; but it has the double advantage of serving as a defence to the hedge, and of raising a bank, which gives additional elevation to the hedge when planted on it. When the shoots are two years old, they may be crossed and fastened by a worsted thread, and they will engraft of themselves; for the friction of the ligature will wound the young bark sufficiently to expose the corticle vessels, and enable them to unite with each other.

Emily. The plants have, then, a double source of life; and, if one of the stems should perish, its branches would be fed by those on which it is grafted.

Mrs. B. Yes; and the dead stem may be cut away without injuring the hedge. By this system of crossing and grafting the branches, the hedge becomes so thick as to be absolutely impassable. Great attention should be paid, not to plant hedges of shrubs which grow thin at the base, or have spreading roots. The hawthorn or quickset is decidedly the plant best adapted for hedges; its shoots branch out in such a variety of directions, and cross and intersect each other so frequently, as to render all ligatures for that purpose unnecessary.

The Paliurus aculeatus succeeds well in dry soils. It is armed with two species of thorn, one of which is straight, the other curved: so that the animal that would trespass, if it can avoid the straight thorns, on entering the hedge, has very little chance of escaping the crooked ones in passing through it.

1741.—What is said of hedges, as defence against thieves? 1742.—And what is said of them, as occasioning a waste of ground? 1743.—How may the shoots in hedges be made to unite themselves together? 1744.—What is said of the hawthorn for hedges? 1745.—And of the Paliurus aculeatus?

The barberry is well adapted for hedges, having three thorns issuing from the same point. The Ilex is furnished with thorns at the extremity of its leaves. The Lentiscus (Pistachia Lentiscus,) and the Cockspur Hawthorn (Cratægus crusgall,) are shrubs which admit of planting in hedge-rows; but their cultivation does not extend further northward than the southern parts of Europe.

Caroline. I begin to think we have been confined long enough by these hedges; and I am impatient to break through them, to get into the orchard, and examine the fruit-trees, which are of a much more interesting nature.

Mrs. B. I was just going to direct your attention to them.

You will be surprised to hear that, of one hundred and twenty families of fruit-trees, known in Europe, we cultivate only seventeen; and by far the greater part of these have been brought from the other quarters of the world. The apple and the pear, some few cherries, and the raspberry and strawberry, are alone indigenous in Europe.

Caroline. Alas! what a poor figure our quarter of the globe makes in the vegetable kingdom!

Emily. We have the greater merit in having enriched it with such a number of foreign plants.

Mrs. B. True. These seventeen families give us thirty-four genera, sixty-eight species, and, finally, about two thousand varieties of fruit-trees: a number which is multiplying every day, from the increased facility of intercourse with foreign countries, and the improved mode of conveying plants, united to the general progress of science.

Caroline. From what countries do we derive our choicest fruit-trees?

Mrs. B. Chiefly from the East. Africa is but very imperfectly cultivated; and America, though so distinguished for its forest-trees, appears to be very scantily supplied with fruit trees. The Opuntia, the Diospyros, and a few others, are the only fruit-trees that have been brought to Europe from the northern parts of the New World.

1746.—Of the barberry, the Ilex, the Lentiscus, and the Cockspur Hawthorn? 1747.—How many families of fruit trees are cultivated in Europe? 1748.—What ones alone in Europe are indigenous? 1749.—The seventeen families furnish how many Genera—how many species—and how many varieties of fruit? 1750.—What is said of Africa and America as furnishing fruit trees for Europe?

The orange and citron we derive from Japan; the pomegranate from Africa.

New Holland, which contains not less than three or four thousand different plants, has but three or four species of fleshy fruit-trees, and the fruit of these is small and insipid.

In some fruits we distinguish those in which the fleshy part is attached to the nut or kernel, as the plum and the peach, and those which are separated from it, as the apricot. Peaches, plums, apples, and pears, are of the family of *Rosaceæ.*

Caroline. This family is, then, equally celebrated for the beauty of its flowers and the excellence of its fruits.

Mrs. B. There are two species of peach, both of which we derive from Persia: one of them, having a smooth skin, we distinguish by the name of Nectarine. Each of these species has two varieties, in one of which the pulp adheres to the stone, in the other it is separate from it.

The other members of this family are the almond, the apricot which comes from Armenia, and the cherry, of which there are five species. There are besides, of this family, the plum, the strawberry, the rose, the service-tree, and the medlar.

The orange forms a family of its own, bearing its name *Aurantiaceae,* and includes the lemon, the citron, and the pample, or mousse.

The sweet orange and the bitter were formerly supposed to be of the same species, and the sweet was often grafted on the bitter orange; but this is an error: they are of different species,—and the sweet orange does not require grafting.

There are no less than twelve known species of walnut-trees; one of which we derive from Syria, and the eleven others from America. We cultivate the first for its fruit, but the latter produce the finest timber.

1751.—From what places are the orange, citron, and pomegranate obtained? 1752.—What is said of the forest trees and the fruit-trees of New Holland? 1753.—Of what family are peaches, plums, apples, and pears? 1754.—What is said of the peaches obtained from Persia? 1755.—And of the almond, apricot, cherry, plum, strawberry, rose, &c.? 1756.—What does the orange family include? 1757.—Of the sweet and bitter orange what is said? 1758.—And of the walnut tree?

CONVERSATION XXIX.

ON THE CULTIVATION OF PLANTS WHICH PRODUCE FERMENTED LIQUORS.

Mrs. B. There exists in all vegetables, though in very different proportions, a saccharine substance from which sugar is obtained ; and this substance is susceptible of being converted into alcohol, or spirit of wine. For this purpose it is not necessary to resort to the laboratory of the chemist: when placed under favorable circumstances, the transformation takes place spontaneously by a process called *fermentation.*

Emily. It is a process with which we are already tolerably well acquainted, as you explained the different fermentations to us in our Conversations on Chemistry.

Mrs. B. You will then recollect that the juice of all fruits when expressed, will, (like that of the grape) ferment; and that during this process a general disorganisation of the parts takes place, and a new arrangement is established, in consequence of which the sugar or saccharine matter contained in the liquor will be converted into spirit. But fermentation is not confined to the juice of fruits: spirit may be obtained from any part of a plant containing the saccharine principle ; thus the sap of the palm-tree, when fermented, produces palm wine.

Caroline. It is to be regretted that we have no trees whose sap can be fermented: it would be so much more easily obtained than fruit.

Mrs. B. The sap of the birch is sometimes fermented. But you may recollect that the vinous fermentation is frequently followed by another of a very different nature, called the acetous fermentation, which reduces the wine or spirit to vinegar: this occurs in some measure with the fermented sap of the birch ; it becomes slightly acid, and may therefore be considered rather as a refreshing than a spirituous beverage. All sap would yield spirit; but, independently of its susceptibility of turning acid,

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1759.—What substance in vegetables may be converted into alcohol? 1760.—By what process may it be done? 1761.—What changes take place in this process? 1762.—How is palm wine produced? 1763.—By what proeess and from what is vinegar produced?

the liquor would, in general, be insipid. The excellence of wine is not confined to the spirit it contains, but to its aromatic flavor; and this is produced by the fermentation of fruit. If spirit of wine alone be required, it may be obtained from potatoes or any other vegetable, however insipid. Brandy and common spirits are, in England, usually distilled from fermented grain: gin has more flavor, as the juniper berries are distilled with the spirit.

Emily. Yet grain does not appear to contain any sugar?

Mrs. B. Though grain is not sweet to the taste, it contains the elements which produce sugar, and the mode of developing this substance, is to make the grain begin to germinate. For this purpose, barley is moistened and exposed to a certain elevation of temperature which stimulates germination; the saccharine principle is thus produced, and the grain becomes sweet: the germination is then suddenly stopped by drying the barley in a kiln or a heated oven; in this state it is called malt. When mixed with water, the liquor is so sweet as to have obtained the name of sweet-wort, and its fermentation produces beer; but this would be a very insipid beverage, were not hops added previous to the fermentation, to give it the flavor and astringent quality found in fruits.

The fermentation of apples produces cider. There are three species of apples, the sweet, the sharp, and the acid. The two former, fermented together, produce excellent cider: the sweet apple supplies the spirit; the sharp, the astringent principle; but the sour apple is not fit for fermentation. In order to make good cider, it is not only essential to choose the races of apples, but they must be gathered with care to avoid being bruised; they should then be collected into heaps, in which state they ripen and exude moisture: they must next be crushed and reduced to a pulp, and 1–20 of water added; the mass is then pressed to obtain the juice, which ferments spontaneously, and produces cider.

Emily. Perry is, I believe, obtained from pears in a similar manner?

1764.—What besides the spirit it contains gives excellency to wine? 1765.—What is said of brandy and gin? 1766.—How can grain be made to produce sugar? 1767.—How is malt prepared? 1768.—How is malt beer prepared? 1769.—How is cider produced, and how many kinds of apples are there? 1770.—In order to make good cider what is to be done?

Mrs. B. Precisely. But it is to the vine that we are indebted for the most precious of our fermented liquors. This plant is of the family called *Sarmentaceæ.* It bears alternately clusters of grapes, and of leaves, opposed to each other on the stem. The vine derives its origin from the countries situated between Persia and India: it was brought by the Phœnicians to Greece, and thence conveyed by the Phocians to a colony they had formed in that part of Gaul, where Marseilles is now situated.

Emily. The vine is a plant of such interest to society, that its history can be traced with more accuracy than that of most other plants.

Mrs. B. Hence governments have interfered more with the culture of the vine, than with that of any other plant Numa Pompilius first introduced it at Rome. The Emperor Domitian ordered all the vineyards to be rooted up. Charlemagne protected the culture of the vine; whilst Charles IX. discouraged it. His successor, Henry IV., re-established it, and ever since it has flourished in France.

Caroline. It appears, then, that cruel and tyrannical sovereigns forbad the culture of the vine, whilst the humane and enlightened ones encouraged it; and yet the former could have been influenced only by its moral effects on their subjects, for it was evidently prejudicial to the interests of the country, to destroy so valuable a branch of commerce.

Mrs. B. Commercial interest was very imperfectly understood in ancient times, especially by unenlightened sovereigns; these, therefore, considered only the prejudicial effects of the vine in producing intoxication, whilst the better informed not only esteemed it as a source of wealth, but of health and comfort to those who enjoyed it without excess,—and this latter class is certainly by far the most numerous.

Emily. I have heard it observed, that there is less intoxication in wine countries than in the more northern districts, which do not admit of the growth of the vine.

Mrs. B. In England, for instance, it is cheaper to drink spirits than wine, or even than strong beer; and as alco-

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1771.—What is said of the growth of the grape? 1772.—From whence does the vine derive its origin, and by what means has it been brought to its present places of culture? 1773.—Who have encouraged the growth of the vine? 1774.—Who have discouraged it? 1775.—What remark does Caroline make on this? 1776.—What is said of ancient commerce as having had a bearing on the culture of the vine?

hol is the intoxicating principle, these distilled liquors have a more intemperate tendency. The culture of the vine, since its introduction into Europe, in extending northwards, has spread itself more to the east than to the west, because the eastern part of this continent is hotter in summer than the western, under the same latitude. Now, the vine derives more advantage from the heat of summer than it suffers from the cold of winter: in the latter season it does not vegetate, so that it requires only the degree of temperature necessary to escape freezing, while heat in summer is absolutely requisite to ripen the grapes; and you have seen that the vine succeeds much better in Switzerland than in England, because, though the winters in the former are generally colder, the summers are hotter.

Caroline. We read in history, of vineyards growing, and wine being formerly made in England. Do you suppose that the climate was then warmer than it is now?

Mrs. B. No; but the palate of our ancestors was probably not so delicate as that of their descendants. The same has been affirmed of Brittany and Normandy, provinces in which vineyards are now unknown, and where the vine is cultivated, as in England, trained against walls in a favorable aspect; and even then the grapes ripen but imperfectly. If wine was really ever made in these countries, it must have been a beverage very analagous to vinegar; but is very possible that such wine was once produced: for the fact is ascertained, that in proportion as the means of transport has increased, the extent of country, in which the vine is cultivated, has diminished.

Emily. I should have imagined that the increase of high roads, canals, and shipping, would, by diminishing the expense of conveyance, lower the price of wine, and thus render it more attainable to the northern countries, where it is not grown.

Mrs. B. Your argument is perfectly just: the increased facility of conveyance augments the demand for, and, consequently, the production of, wine; but that does not prevent its restricting the extent of latitude in which the

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1777.—And of the cheapness of different kinds of drink in England? 1778.—Why does the vine extend itself more to the east than to the west of Europe? 1779.—What comparison is made between the growth of the grape in England and Switzerland? 1780.—Why is not the vine cultivated in England as formerly? 1781.—If wine were ever made in Brittany and Normandy, of what description must it have been?

vine is cultivated. When wine could be conveyed from the south of France to Brittany and Normandy, of a much higher flavor and better quality, than that which was produced in those provinces, and with but little additional expense, the Bretons and Normans gradually converted their vineyards into corn and pasture, and exchanged their grain and cattle for the juice of the grape.

Caroline. Whilst the increased demand for wine, must have induced the southern districts to convert their pasture and cornfields into vineyards. The same reasoning will hold good with regard to England; and wine must have been conveyed across the Channel, to the utter destruction of the English vineyards. You see, Mrs. B., that I have not forgotten your lessons of political economy.

Mrs. B. I am glad to hear you remember them so well: the cultivation of vineyards at present extends from 29° to 50° of latitude, as far south as Shiraz, in Persia; as far north as Cologne, on the Rhine.

Emily. Pray, does not the vine grow naturally in America?

Mrs. B. It does; but it is of a different species; and grows only wild; the vine which is cultivated, is brought from Europe; but its introduction has not hitherto been attended with complete success.

Emily. I am surprised at that, as the islands of the Atlantic, Madeira, and the Canaries are so celebrated for their wine.

Mrs. B. On the continent of America, all the grapes in the same cluster frequently do not ripen at the same time; so that, when gathered, some are decaying, whilst others are not yet come to maturity: and this circumstance which is not yet accounted for, prevents the wine from being of a good quality.

It is at the Cape of Good Hope that the vine has made the most remarkable progress, and particularly since England has been in possession of that colony. Whilst it be-

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1782.—Why have wines been so much carried from the south of France to the more northern parts of Europe? 1783.—Into what use have the Bretons and Normans consequently converted their vineyards? 1784.—How does Caroline apply this reasoning to England? 1785.—Over what regions does the cultivation of the vine now extend? 1786.—Emily asks—if the vine grows naturally in America—What is the answer? 1787.—What circumstance respecting the American grape is mentioned, which injures the flavor of the wine?

longed to the Dutch, it produced only a small quantity of rich Cape wine; but now a variety of different vines are cultivated there with great success, and the Cape Madeira will, perhaps, ultimately rival that of the Atlantic island.

The height at which the vine can be cultivated, from the level of the sea, is four hundred fathoms.

Emily. But that must vary according to the latitude?

Mrs. B. No doubt; this is the elevation of the most northern limits of the cultivation of the vine in France. There are many circumstances to be attended to, in the culture of a plant of so much importance as the vine. In the first place, the nature of the plant: the varieties are innumerable; there are no less than six hundred in the botanical garden in Geneva; the fruit differing either in color, form, flavor, consistence, &c.: the degree of flavor of firmness and compactness of the fruit, is, in general, proportioned to the heat of the climate. The flavor of the muscat grape is, however, richer than that of the common grape in any climate.

Every flower of the vine contains five seeds, two or three of which often fail.

Caroline. The soil must labor hard to ripen so many seeds?

Mrs. B. No cultivation requires greater care to repair the exhaustion which it undergoes, and attention to prevent weeds from engrossing any portion of that food which is so much in request. Yet a great deal of manure should not be used, for it injures the quality of the fruit, though it increases the quantity.

The grapes should be neither very close, nor very distant from each other in the cluster, but so far apart as to leave sufficient space for each grape to attain its full growth. For this purpose, the grapes of Fontainebleau, when young, are thinned by the scissors. But these grapes are cultivated exclusively for eating, and are sold at a price which repays such an expensive mode of culture.

1788.—What is said of the vine at the Cape of Good Hope? 1789.—At what height from the level of the sea may the vine be cultivated? 1790.—How many varieties are there of the grape in the botanical garden of Geneva? 1791.—To what is the firmness and compactness of the fruit owing? 1792.—How many seeds does each flower of the vine contain? 1793.—How does the growth of the vine effect the soil? 1794.—What is said of grapes, as to their distance from each other? 1795.—How is this effected at Fontainebleau?

There is also great diversity in the degree of precocity or tardiness of this plant. When it shoots early, there is danger of its suffering from the frost in spring; if late, it may not have time to ripen its fruit in autumn. Care, therefore, should be taken to choose the medium, especially in cold climates.

Old plants produce the finest fruit, but in the smallest quantity. It does not, therefore, answer, to continue to cultivate the same plants, above a certain number of years.

Caroline. So that they are not allowed time to meet in the course of nature with their accidental death?

Mrs. B. Not often. The influence of climate on the vine is very considerable. The greater the degree of heat, the more sweetness is developed in the fruit, the greater is the quantity of alcohol produced by fermentation, and the astringent principle is proportionally diminished: but this may be carried too far; a certain admixture of the astringent principle is both wholesome and palatable. The grapes of Fontainebleau will not produce good wine, from not possessing a sufficiency of this principle; and, accordingly, we find that the wines in highest estimation are not those produced in the hottest climates, but in countries situated between 30° and 45° of latitude. The aspect most favorable must be determined by the locality of the situation and the latitude. The vines of Epernay, which produce the finest champagne, have a northern aspect; those situated on the two opposite banks of the Rhone, in the neighborhood of Avignon, yield equally good wine: but, in colder climates, the more vineyards are exposed to the south the better they thrive.

It is rather singular, that fine grapes may be produced in almost every kind of soil, provided the vine be of a nature to suit it. The vineyards of Bordeaux are planted in a gravelly soil, and hence bear the name of *Vin de Grave;* Those of Burgundy in calcareous clay; hermitage grows in granite; and Lacryma Christi is raised in the volcanic soil of Mount Vesuvius. The vineyards of Switzerland grow in stiff, compact, calcareous earth.

1796.—What is said of the precocity or tardiness of this plant? **1797.** Of old plants what is said? **1798.**—What effects are produced on this fruit by the influence of climate? **1799.**—Where are wines of the best quality produced? **1800.**—What is said of the vines of Epernay, the banks of the Rhone, and Avignon? **1801.**—What is said of the nature of the soil in relation to the culture of the vine?

In order to determine upon the mode of culture, the question must first be ascertained whether it be grapes of the finest quality or in greatest quantity that are required. In hot countries, the former are most in demand; in cold countries, the latter is principally aimed at: for in districts which form the limits of the cultivation of the vine, it is desirable to produce a large quantity of wine, though it be of inferior quality, for the beverage of the common people, who cannot afford to pay the conveyance of wines from more favorable climates.

An argillaceous soil produces but indifferent grapes, even in a favorable climate. Under such circumstances, therefore, quantity rather than quality is aimed at, in order to obtain spririt for brandy; for in wine countries brandy is distilled from wine rather than from grain. For this purpose, the plants, instead of being kept low, as you have seen in France and Switzerland, are allowed to grow to a great length, and are suspended in garlands from one tree to another.

Caroline. This mode of cultivation is adopted in Italy for the production of grapes for wine, and is most beautiful in appearance.

Mrs. B. But the fruit is not of so fine a quality; and, consequently, the wine is not so good. In the south of France, as well as in Italy, vines are often cultivated without being propped, and the branches are suffered to grow six or eight feet in length.

During the wars of the Revolution, the French having destroyed all the props of the vineyards in the valley of the Rake on the banks of the Rhine, the peasantry were obliged to let the vines grow without support; when, instead of being deteriorated, they found the fruit so much improved, that they have ever since continued the same system.

Emily. Then I conclude that they did not allow their vines to shoot out to a great extent.

Mrs. B. No doubt; or the fruit would have been impoverished, instead of being improved. The use of props in vineyards is, perhaps, carried to the extreme. M. De

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1802.—What question must first be settled in order to determine the mode of culture? 1803.—What is said of the argillaceous soil? 1804.—When grapes are raised for brandy how may be regulated the length of the vine? 1805.—What is said of propping vines in France and Italy? 1806.—And of the growth of the vine during the French Revolution?

Candolle suggests the experiment of fastening four plants to one prop, placed in the centre. In doing this, the branches would be curved towards the prop, and the descent of the cambium retarded.

Caroline. We have seen vineyards in some parts of Italy trained on a horizontal trellis-work, the grapes being suspended beneath the verdant roof. In other places, the vines are trained over trees, which are planted merely to afford them support, and they derive a little shelter from the leaves, which grow on the few branches which are not lopped.

Mrs. B. These various modes of training vines, though they may be used in hot climates with less injury to the fruit, never fail, more or less, to be prejudicial to it; and though the climate of Italy is generally hotter than that of France, the latter is celebrated in all parts of the world, for the excellence of its wines, while those of the former are scarcely ever exported.

In hot climates, the grapes are sweet, contain less acid and astringent principle, and the fermentation is less complete, the proportions not being so well adjusted as in France, and other countries of a more moderate temperature.

It will be unnecessary for me to enter into any further detail on the nature of the vinous fermentation, as it is a chemical process, an account of which, you may recollect, I have formerly given you.

CONVERSATION XXX.

ON THE CULTIVATION OF GRASSES, TUBEROUS ROOTS, AND GRAIN.

Mrs. B. The objects of culture which we shall next investigate are the grasses.

The principal use of the grasses is to feed cattle, which, both during their life and after their death, are useful to us in so many different ways. The advantage we derive from them in agriculture is not confined to the labor they

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1807.—What does Candolle say of propping vines? **1808.**—How do these modes of training vines effect the fruit? **1809.**—How is the flavor of grapes in hot climates? **1810.**—What are the different ways in which the grasses are advantageous in agriculture?

perform in the field; they also supply manure; and the more forage we produce for cattle, the greater is the quantity of manure we shall be able to spread upon our fields.

Emily. Poor soils, then, must require more cattle, and, consequently, more grass-land, than rich ones. But may not cattle be fed on other vegetables besides grass?

Mrs. B. Unquestionably; cattle will eat the same vegetables that serve for our subsistence; but we reserve these for our own use, and feed them on those which would afford us little or no nourishment, such as grasses. These are of two kinds, natural and artificial. The natural grasses are of the gramineous family, which belongs to the class of monocotyledons, or endogenous plants.

Emily. Yet how very little resemblance they bear to the palm-tree, or other tropical endogenous plants.

Mrs. B. They are not so dissimilar as you imagine, since they grow like them internally.

Caroline. They may then be considered as the miniature palm-trees of our ungenial climates, being contracted both in space and time; for the mower comes with his destructive scythe, before they have passed through a single season.

Mrs. B. The natural grasses are either annuals or perennials. The first are very rarely used for meadows. In some countries, however, rye, Indian corn, and millet (all of which are annuals,) are sown as grasses; that is to say, for the sake of their leaves, which are mown as soon as they appear above ground, and thus, several successive crops are obtained in one season.

But our meadows are all formed of perennial grasses: they are sown with hay-seed, which consists of a mixture of various sorts of grasses, more or less adulterated with the seed of weeds. These different grasses, ripening at different periods, a medium must be taken to mow the crop.

Emily. Would it not be better to sow only one species of grass?

Mrs. B. Yes; provided it were first ascertained, what species would best suit the soil and climate. There are

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1811.—Why are not cattle fed on the vegetables which serve for our own subsistence? 1812.—What are the two kinds of grasses? 1813.—How are natural grasses divided? 1814.—How may rye, Indian Corn, and millet be considered as grasses? 1815.—Of what grasses are our meadows formed?

some agriculturists, however, who dispute this opinion, and think that a variety of grasses makes the best fodder for cattle. Several naturalists are now engaged in endeavoring to raise very pure unmixed grasses, with a view to produce seed for sale: a measure which will greatly tend to the improvement of meadows.

Caroline. Do not meadows occasionally require to be sown afresh? for as the crops are either pastured or mown before the seeds are ripe, it cannot re-sow itself; and the grasses, though perennials, do not, I suppose, last a great number of years.

Mrs. B. Grasses are renovated, not so much by seed as by means of their roots and subterraneous branches, which spread out in various directions, interweaving and forming a sort of network of roots and branches; and from this reticulated mass spring abundance of new shoots, which thicken and renovate the meadow. If grass be kept short, it consumes less nourishment, and a greater quantity remains to push out fresh shoots.

Emily. This accounts for the fine thick turf of which our lawns are composed, and which, being so continually mown or fed off by sheep, precludes the possibility of their ever re-sowing themselves.

Mrs. B. This, however true in England, where the climate is temperate and moist, will not hold good in countries where the grass is burnt up in summer, when mowing cannot take place; and it is for this reason that it is impossible on the Continent to produce those beautiful lawns, so ornamental to our country seats.

These lawns, when first prepared, are not usually sown, but the grass is laid down in sods. By this means the roots are obtained ready matted, together with a thick fine turf, which it would require many years' growth, and constant mowing, to produce from seed.

Meadows are mown in England but once, or, at most, twice in the season; whilst, in many parts of the Continent, three or four crops are obtained, according as the soil is dry or moist, elevated or low.

1816.—Emily asks, if it would not be best to sow only one species of grass? 1817.—How are grasses renovated? 1818.—Why cannot beautiful lawns, like those in England, be produced on the continent of Europe? 1819.—How are these lawns prepared? 1820.—How many times are meadows mown? 1821.—What grasses are best adapted to meadows?

The Phleum, the Dactylis, the Anthoxanthum, and Rye-grass, are the plants best adapted for meadows; but Rye-grass, degenerates in the dry warm climates of the Continent, as it requires a great deal of moisture to keep it fine and tender.

Emily. The great defect of grass, which I have observed both in France and Switzerland, is the quantity of weeds which are mixed with it, and which renders the hay strong and coarse.

Mrs. B. That is owing to the impurity of the seed, and is attended with every possible disadvantage. The coarse leaves of the weeds are not only unpalatable and unwholesome for cattle, but in growing they fill the spaces which the grasses would occupy, and, by separating them, prevent their roots from combining and giving rise to new shoots.

There are some meadows which, from peculiar circumstances, are not susceptible of being mown. The grass of mountains, for instance, does not grow sufficiently high to require it. Being frequently covered with mists, it remains green throughout the summer; much resembling our English lawns, and affording delicious pasture for cattle when the meadows in the valleys and plains are burnt up. The fine turf on the mountains of Switzerland and the Alps, consists principally of phleum, intermixed with other herbs of an inferior quality. The matted roots of these grasses are extremely useful in preventing the surface of the soil from being washed down by rains: the meshes of the net work which they form confine the earth and retain it, as it were, in a basket on the surface of the declivity. It is on this account very imprudent to attempt tillage on the sides of mountains. Small flat patches of land, which are occasionally met with in such districts, may be cultivated with advantage, but it is dangerous to displace the fence which Nature has provided; and however inadequate the means may appear to the end, it is certain that the massive mountains are upheld, by the feeble roots of some of the smallest of the vegetable species.

Emily. That is, indeed, wonderful! but it is merely the surface of the soil which the roots of the grass support.

1822.—To what are weeds in grass owing, and what is said of them? 1823.—What is said of mountain meadow grass? 1824.—And of the matted roots of these grasses? 1825.—And of the stability they give to the mountains?

Mrs. B. True; but if one surface were washed down, another would be exposed to the same danger; and thus, in the lapse of time, successive surfaces would be destroyed, and the mountain finally be brought low!

Another species of meadows incapable of being mown are common fields, every parishioner having a right of pasturage; a circumstance which renders this species of tenure extremely disadvantageous: it is, in fact, condemning the land to yield as little produce as possible.

Let us now proceed to the artificial grasses, the most benevolent of all the vegetable tribe. It is to them that we are indebted for repairing the injury which the land sustains from the culture of grain. They were first introduced into France by the celebrated agriculturist, Olivier de Serres, in the sixteenth century.

Emily. These grasses do not, I suppose, form permanent meadows, but are sown alternately with crops of corn, in order to recruit the soil after the exhaustion it has undergone from the latter.

Mrs. B. Certainly: thus alternated, they form an excellent course of cropping. Most of the artificial grasses are of the leguminous family; among these the vetches and the scarlet clover are annuals. The common purple clover lasts two or three years. It is difficult to obtain the seed unadulterated by that of other plants. Clover has long been cultivated on the left bank of the Rhine, for the sole purpose of producing seed for sale: this commerce was chiefly carried on with England; for though we cultivate a considerable quantity of clover, we use it, almost wholly, as food for cattle; our summers seldom being hot enough to ripen the seed, so that we are obliged to have recourse to that of foreign growth. A very profitable trade was carried on with us in this article, when Buonaparte issued his decree against exportation, and the poor agriculturists on the left bank of the Rhine, then under the dominion of France, were nearly ruined. The Germans, on the opposite bank, supplanted them in a

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1826.—How can they be of so much use, as they confine merely the surface of the soil? **1827.**—What does Mrs. B. say of common fields? **1828.**—Who introduced artificial grasses into France, and what is said of their importance? **1829.**—Of what family are most of the artificial grasses, and what is said of vetches, scarlet clover, and purple clover? **1830.**—How has clover been cultivated on the left bank of the Rhine? **1831.**—How was the trade in the seed of clover with England interrupted?

branch of commerce they were compelled to abandon: England continued to be equally well provided with clover seed; and it was Buonaparte's own subjects who alone suffered by his absurd prohibition.

Saintfoin, or Esparcette, is another artificial grass of the leguminous family, of longer duration than clover. The seed appears larger than it really is, because it is sown with the husk or pericarp, and no less than twenty pounds of seed is required per acre; whilst ten or twelve pounds of clover seed, which is sown without the husk, is sufficient.

Lucerne, also of the leguminous family, lasts from twenty to thirty years, according as the soil is more or less favorable to it.

Emily. It is then too long lived to enter into a course of cropping?

Mrs. B. In some parts of the valley of the Rhine, these courses are made of thirty years' duration, twenty of which is occupied by lucerne. The roots of this plant strike twelve or eighteen feet into the soil; a depth at which moisture is always found, so that lucerne is enabled to resist drought much better than clover, whose roots are more superficial. Yet, if the season be dry, there is some danger of its failing the first year of its growth, the roots not having reached a depth of soil which is always moist. The seed for sowing should be chosen of a bright yellow color, and heavy; a caution necessary to be attended to, in the choice of all seeds. Lucerne is mowed from three or four, to seven or eight times in the year, according to the climate in which it grows. Its herbage is less delicate than that of saintfoin.

Caroline. Have we not seen lucerne growing as a shrub in some parts of Italy?

Mrs. B. This is of a different species; it is naturally a shrub, and grows wild on the sea-coast in Italy, where it is used as fodder for cattle. Furze may also be cultivated, either as a shrub or as artificial grass. In the latter state, it should be mown very young, while still soft and tender; after growing three years it is rooted up, but it prepares the soil admirably for grain.

1832.—What is said of Saintfoin? 1833.—How long does Lucerne last, and what else is said of it? 1834.—In the valley of the Rhine, what is said of its growth, the length of roots, &c.? 1835.—When is there danger of its suffering from drought? 1836.—How frequently is it mowed? 1837.—What is said of it as a shrub in Italy and of the culture of furze?

There are some artificial grasses which are not leguminous. *Burnet* is of the family of *Rosaceæ:* it has the advantage of thriving in calcareous soils.

The wild endive, and, indeed, the leaves of almost any plant, are susceptible of being cultivated for forage; excepting those which have either milky or astringent juices, such as the leaves of the fig, or the oak: cattle will not eat them; or at least not unless they are mixed with a considerable proportion of good forage. But without cultivating them as grasses, the young leaves of the ash, the willow, and the acacia, gathered from the tree, make very wholesome food for cattle.

Emily. In Italy, the cattle are very commonly fed on the leaves of trees; and I have often observed, with admiration, the industry of the Tuscan peasants, who collect green weeds, the clippings of hedges, and the leaves of trees, in order to supply their cattle with food.

Mrs. B. The small size of the Tuscan farms, which seldom exceed fourteen acres, do not admit of meadow land, excepting the grass walks with which they are intersected. The nearer we approach the tropical climates, the more we find meadows, both natural and artificial diminish: the climate becomes too hot and dry for the cultivation of grasses.

We have observed, that there are some species of plants which afford food, both to men and cattle. These are the class of tuberous roots, which constitute one of the most valuable of the gifts of nature. The potatoe, the turnip, beet, and carrot, all belong to this class. Were these vegetables cultivated only in quantities sufficient to supply the wants of the human species, they would be considered as a most valuable acquisition, by varying, in a salutary and palatable manner, our stock of vegetable food. But when produced in such abundance that it is applied also to the sustenance of cattle, it not only extends the benefit to a lower order of beings, but furnishes, in case of need, a store of food for man; the accidents which injure the crops of corn being seldom hurtful to tuberous roots.

1838.—And of burnet? 1839.—And of endive? 1840.—What leaves may be cultivated for forage, and what ones may not? 1841.—Of meadows in tropical climates what is said? 1842.—What tuberous roots are mentioned and what is said of them? 1843.—If raised in great abundance, what is the consequence?

Caroline. And, should both fail, we have the resource of feeding on the cattle, who are themselves deprived of food.

Emily. It is this, no doubt, which explains what appeared to me very unaccountable,—that meat is sometimes cheap, when bread is dear.

Mrs. B. If forage fail, whether it be owing to a scarcity of grasses or of roots, a greater number of cattle will be sent to market, and the meat will consequently be low priced, but it will be of inferior quality; for, under such circumstances, the cattle cannot be fattened.

The culture of tuberous roots requires very deep ploughing. Beet is of various colors, most commonly of a rich crimson. It is raised from seed, and the young plants afterwards thinned: the soil should be neither very moist nor very dry: the seed ripens only the second year. This plant contains so great a quantity of saccharine matter, that, during the prohibitory system of Buonaparte, the French had recourse to it for the fabrication of sugar. Indeed, the manufacture is still carried on, and I understand that some recently-discovered mode of facilitating the process enables them to compete with the West Indian market.

There are three species of turnips;—*turnips*, *Swedish turnips*, and *the Kohl Rabi*, or turnip-rooted cabbage. The leaves of the first are rough and hairy, those of the second smooth, and those of the last form a medium between the other two, being hairy when young, and becoming smooth afterwards. There are many varieties of turnips; the white are the most delicate, the yellow the most robust: they require a light loose soil, and a good deal of manure; for being of the cruciform family, which contains *azote*, they must be furnished with the means of obtaining this element, and it is animal matter which yields it in greatest abundance.

The *Topinambour*, or Jerusalem artichoke, produces a great number of tubers, which are much eaten in England, but they are not relished on the continent. This plant is cultivated in some parts of America, and is brought to Europe from the mountains of the Brazils.

1844.—If forage is deficient what will be the consequences? 1845.—Of the raising of beets what is said? 1846.—And of their being cultivated for sugar, what is said? 1847.—What are the three species of turnips? 1848.—And of the different varieties of turnips, and of the mode of cultivating them? 1849.—Of the Jerusalem artichoke what is said?

Carrots require a light but not a loose soil: they are rather of a delicate nature, suffering both from excess of cold or of heat.

The potatoe, is universally acknowledged, we derive from America, but from what part is not well ascertained; for it is remarkable that neither M. Humboldt, nor any other traveller in that country, has met with it in its wild state. Clusius the first botanist who speaks of potatoes, says that they were introduced into Europe by the Spaniards, in 1588. Sir Walter Raleigh brought them from Virginia to England and Ireland, where their cultivation succeeded much better, and they were more liked than on the Continent of Europe; and it is we English, who have subsequently been the means of introducing a taste for them, into other countries.

Emily. In Italy the lower classes are still much prejudiced against potatoes, considering them as food fit only for hogs or cattle.

Mrs. B. There are from one hundred to one hundred and fifty varieties of this plant which differ in color, form, precocity, &c. Potatoes are usually raised from germs, contained within the tuber, and commonly called eyes: these germs contain the rudiments of the young plant, similar to the buds or the branches of a tree. In order to make them sprout, the potatoe must be planted either entire or cut in pieces, leaving an eye in each piece, from which the young plant shoots; or in case of scarcity, the eye alone may be planted, reserving the fecula or mealy part for food.

Emily. I thought that the mealy part was a magazine of food for the young plants which shoot from these germs, and was, therefore, necessary to their developement.

Mrs. B. That is true; and the plant will shoot with much more vigor if the fecula remain attached to it; it is not, however, absolutely necessary: for the eye, if planted naked, has the power of absorbing moisture on which it feeds, till it has struck out roots, which supply it more regularly with nourishment. Potatoes may also be raised from slips, and as a last resource the seed may be sown;

1850.—And of the culture of carrots? 1851.—When, and by whom was the potatoe introduced into Europe? 1852.—How is it esteemed in Italy? 1853.—How many varieties are there? 1854.—From what are they usually raised? 1855.—Will potatoes, if the eye only is planted, flourish as well as though the whole potatoe were planted? Why not?

but this is so slow a process, that it is resorted to only with a view of procuring new varieties. Though the potatoe bears the name of tuberous root, the bulb does not grow upon the root of the plant but on the lower branches, which bury themselves under ground: in cultivating the potatoe, it is necessary to hoe up the earth over these branches, in order to cover them more completely. There is a small tubercle produced by the potatoe-plant at the axilla of the leaf, which being exposed to the light becomes green, and is of so acrid a nature as not to be eatable. Half the weight of the potatoe consists in fecula: the saccharine principle may be developed in this tubercle as it is in barley; it will not produce wine, but spirit may be distilled from it when fermented; and the residue affords excellent food to fatten hogs. The other half of the potatoe consists in fibrin and mucilage. From eight to ten pounds weight of potatoes per day is a proper quantity to give to cattle when there is a sufficiency of hay to mix with it; but, in case of a scarcity of the latter, they will consume from eighteen to twenty pounds of potatoes without inconvenience.

We may now proceed to the examination of one of the most important of the vegetable productions in civilised countries,—I mean corn. We have hitherto considered gramineous plants as cultivated only for their leaves, under the name of grasses: but there are many of this family whose seeds are large enough to afford food for man, and it is with this view that he cultivates them. These are distinguished by the name of grain or corn, in Latin *Cerealia*, from Ceres the goddess of plenty, who is said to have first introduced corn into Sicily; but whence it originally came is unknown, it having never been found growing in a wild state. Some naturalists are of opinion that we derive grain from the mountains of Persia and Thibet; a species of wheat, the *Triticum Spelta*, commonly called *Spelt*, having been found growing wild in those countries. Others derive its origin from Tartary.

As corn belongs to the class of monocotyledons, the

1856.—By what other means may potatoes be produced? 1857.—What is said of the small turbercle at the axilla of the leaf? 1858.—Of what do the two halves of potatoes consist? 1859.—How has corn hitherto been considered? 1860.—From what places has it been supposed that corn was derived?

stems have no bark; but these tall and slender stalks derive their stability from a quantity of silex, which, not being of a volatile nature, is deposited on the surface of the straw or *culm*, when the more volatile parts evaporate. Here it accumulates, and in the course of time incloses the straw in a species of coat of mail, which not only enables it to resist injury, but also to support the weight of seed it has to bear.

Emily. Were it not for this provident supply of Nature, it is true that a slender hollow straw would be quite unequal to support the burden of a heavy ear of corn.

Mrs. B. In this and all northern countries, the straw is generally hollow, but in warm climates it is full. The stems of gramineous plants are also intersected with knots or articulations, designed, no doubt, to add to its strength; and each of these, shoots out a long slender leaf, which encloses the stem like a sheath.

Grain constitutes the fruit of corn, and consists, consequently, of the seed and its pericarp: these are so closely attached together that they are not easily separated or distinguished from each other, when in the state of grain: but when ground into flour, it is the pericarp which forms the coarse bran; and the seed, the flour used for common household bread.

Emily. This flour then consists of the contents of the seed together wirh its spermoderm: and it is, no doubt, the latter which renders it brown?

Mrs. B. You are right; in order to obtain the whitest wheaten flour, such as the bread in London is made of, the spermoderm, which forms a finer species of bran, must also be subtracted: all this is very adroitly performed by that skilful naturalist the miller, with his sieve of moulting cloth.

Emily. How admirably this seed is protected! it is true that it is one of great importance to mankind: but is it not curious to think that so small a body as a grain of corn should have two coverings, consisting each of three coats?

Caroline. And the husk, besides, for an outer garment. I thought it had been the husk which formed the bran.

1861.—From what do the stalks of corn derive their stability? **1862.**—How does the straw, as to solidity, vary in different climates? **1863.**—Of what does grain consist? **1864.**—What parts form the coarse bran, and what the flour? **1865.**—How is the finest wheaten flour obtained?

Mrs. B. No, my dear: the husk constitutes the chaff which is separated from the grain by the operation of thrashing.

It is only in one species of corn, the *Triticum Spelta*, which I have just mentioned, that the husk adheres so firmly to the grain as to require a peculiar process of grinding, in order to part them. This renders it less liable to the depredations of the feathered tribe, who can easily pick out the naked grains of wheat from the ear; but find it very difficult to dislodge those of *epotre* from the adherent husk.

The seed contains the embryo plant and the albumen, which is to afford it the first nourishment, and this we have already said consists of fecula and gluten.

Caroline. Since the albumen supplies so ample a provision for the young plant, the cotyledon of corn is not, I suppose, of a succulent nature?

Mrs. B. I beg your pardon; but it is so minute as to afford but very little sustenance.

The beard of corn is formed by the prolongation of the husks; it is not improbable that all species of grain was originally bearded, and that many of them lose this appendage when cultivated in good soil.

Caroline. The beard, then, I dare say, is the result of a degenerated organ, like thorns or tendrils.

Mrs. B. Very likely; or at least that in a state of cultivation it disappears. Of the two species, bearded corn is by far the more robust; but it has the inconvenience of being subject to retain moisture, so that in a wet summer it is much more liable to injury.

Grain may be divided into three series:

First. That whose flowers have both pistils and stamens, and are aggregated in the form of ears.

Second. That with similar flowers, but in the form of clusters or bunches.

Third. That in which the pistils and stamens are situated in different flowers.

In the first series, which comprehends wheat, barley and rye, there are slits or cavities along the axis of the

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1866.—Of the Triticum Spelta, what is said? **1867.**—What protection does the husk afford? **1868.**—What does the seed contain? **1869.**—How is the beard formed, and what is thought not improbable as to all grains having been bearded? **1870.**—What is said comparatively of bearded corn? **1871.**—What are the three series into which grain may be divided?

ear, whence issue smaller ears or earlets: in the spring these put forth a little flower, and sometimes several, each of which contains a single grain, enclosed in a husk; these form the aggregated ear. The flowers have three stamens, and one pistil with two stigmas. The grain of wheat is of an oval form, that of epotres, rather triangular.

Emily. Is not the wheat sown in autumn more hardy than that which is sown in spring?

Mrs. B. There is no difference in them whatever, excepting that the former ripens earlier.

The largest grains of corn should always be selected for sowing, because the pericarp does not increase in size in proportion to the seed.

It is the gluten contained in the grain of wheat which produces the fermentation of bread: this process is vulgarly called raising the bread; and it is true that the disengagement of carbonic acid, which takes place during fermentation, actually raises the dough, producing those hollow interstices which render bread light and digestible. Other species of corn do not make such good bread, as they contain less gluten.

Emily. I recollect, during a scarcity, potatoes being mixed with wheaten flower to make bread; but it rendered it very heavy and unpalatable.

Caroline. I thought that yest, the produce of the fermentation of beer, was commonly used to excite that of bread.

Mrs. B. It is so in England; but it acts merely as a stimulus to hasten that of the gluten. On the Continent, and in wine countries in general, where beer is little drunk, the fermentation is excited by means of leaven, which consists of a piece of dough that has been kept from a former batch of baking, and has turned sour; or, chemically speaking, undergone the acetous fermentation. Now there is so much analogy between the acetous fermentation and that of bread, that it is sufficient to place a body which is under-going, or has recently undergone

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1872.—What are included in the first species and what is said of them and their growth? 1873.—How does wheat sown in autumn and spring differ? 1874.—What corn should be selected for seed? 1875—What in the grain of wheat produces fermentation of bread? 1876.—Why do not other species of corn produce as good bread as wheat? 1877.—On the continent of Europe how is fermentation caused? 1878.—Between what is there an analogy in relation to this subject, and what follows from it?

the former, in contact with dough to excite it to ferment, and this may be done either with yest or leaven.

Caroline. It is, then, a sort of contagion which these bodies communicate to the dough; but is it not surprising that it should render the bread light and wholesome, instead of turning it sour?

Mrs. B. Were the fermentation of the dough not interrupted by baking, it would become sour, as that portion does which is reserved for leaven. The fermentation of bread is by some chemists considered as a commencement of the acetous fermentation. There must, however, I conceive, be some difference between these processes, as in the regular succession of fermentations, the acetous is always subsequent to the vinous; and bread is so perfectly insipid that there is no reason to suppose it has undergone the latter.

Emily. Yet wheat is, I suppose, like other kinds of grain, susceptible of undergoing the vinous fermentation.

Mrs. B. Certainly; alcohol may be obtained from all kinds of grain. There are four species of wheat.

First. The common wheat, whose ears are erect, and its grains obaque and obtuse.

Second. The Triticum turgidum of Limoges, which the French call *Gros bled,* whose ears are thicker and larger; it contains less gluten, and, consequently, is not so well calculated for bread; but is much used on the Continent to thicken soup or porridge. This wheat, if cultivated in a very rich soil, produces a variety called *miraculous wheat,* the ears of which are branching from the abundance of their produce.

Third. *Bled dur,* or hard wheat: the grain is semi-transparent; it has still less gluten than the preceding: it is of this species that macaroni, vermicelli, and all the Italian pastes are made: it requires a dry soil and a warm climate, and thrives best in the southern parts of Europe.

Fourth. Polish wheat: it grows very plentifully in Poland, and is thence exported to other countries; but being of inferior quality, it is little cultivated elsewhere.

1879.—If the fermentation of dough were not interrupted by baking what would be the consequence? 1880.—What is the opinion on the subject of fermentation in bread, and why is this opinion thought erroneous? 1881.—Can alcohol be obtained from all kinds of wheat? 1882.—What is the first of the four species of wheat? 1883.—What is the second, and what is said of it under different circumstances of culture? 1884.—What is the third and what is made from it? 1885.—The fourth, and what is said of that?

Spelt contains less gluten than other species of wheat: it affords beautifully white flour for pastry, and is also much used for starch.

Emily. I should have thought that it would have required more gluten to make starch than to make bread?

Mrs. B. No; starch consists almost wholly of pure fecula, and may be obtained from potatoes as well as from wheaten flour.

Rye is of so hardy a nature that it accommodates itself to almost all soils and all climates: its straw is longer and firmer than that of wheat, which renders it peculiarly adapted to thatching: it contains so little gluten that it cannot be made into bread without an admixture of wheat.

Emily. It is, then, no doubt, on this account that the poor Scotch Highlanders, who cannot afford to mix wheaten flour with it, eat it baked in cakes instead of bread.

Mrs. B. It is chiefly oats, I believe, that are thus eaten in Scotland.

Barley is principally used for fermentation. It contains a great quantity of saccharine matter: mixed with hops we have seen that it produces beer; and it is also distilled for spirits.

In the second series of corn, the grain grows in the form of clusters, each earlet having a separate pedicle or foot-stalk.

This series contains four genera.

First. Oats: the husks or glumes have two valves and beards springing from the back part of the husk, instead of growing from the summit, as with barley and rye. Oats afford food both for man and for horses.

Second A species of oats derived from Asia, the earlets of which incline all in one direction: it is more robust than the preceding, yet it is very liable to be attacked by the disease called *smut.*

Third. The Phalaris of the Canary Isles, commonly called Canary seed, used chiefly as food for the birds, for which those islands are so celebrated.

Fourth genus. Rice, which we derive both from the East and West Indies. Next to the Banana or bread tree,

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1886.—Of spelt what is said? 1887.—Of what does starch consist? 1888.—What account is given of rye? 1889.—And of barley? 1890. —In the second series of corn how does the grain grow? 1891.—What is the first of the four genera of this species? 1892.—What is the second and what is said of it? 1893.—What is the third?

this is the plant which affords the greatest quantity of wholesome nourishment, and is, perhaps susceptible of the greatest variety in the mode of cooking; for being itself insipid, it admits of all kinds of seasoning.

Emily. How much, then, it is to be lamented that its cultivation should be unwholesome!

Mrs. B. It is so only at that period when the water is drawn off to enable the grain to ripen. It is sown in the spring in a muddy soil; and as the plant grows, the water is let on, and gradually raised so as to keep it almost wholly covered, until the grain begins to ripen. I have been informed that in the rice plantations of Lombardy, the mortality is not greater than in the adjacent districts: it is true that the inhabitants of the latter are in a wretched state of poverty, whilst the cultivators of rice are at least supplied with plentiful nourishment, to compensate for the unwholesomeness of their occupation. I should not wish to extend the culture of rice in Europe, in soils adapted to other produce, but, as this plant will grow only in marshy districts, it is as well to convert such land to so useful a purpose; for it is not more unhealthy as rice fields, than as marshes. One great objection to the cultivation of rice is, that it injures the surrounding soil by the filtration of the waters, which, in the course of time, destroys all the trees in the neighborhood.

Caroline. But such a filtration must be very advantageous to meadow land?

Mrs. B. When confined within due limits; but we must remember the old adage, 'Too much of a good thing is good for nothing:' the adjoining meadows would eventually become converted into marshes, so that there would be no other resource than to extend the cultivation of rice; and the evil would thus always go on increasing, if government did not interfere to prevent it.

The third series of corn, having the pistils and stamens in different flowers, consists of maize or Indian corn, Canada rice, Sorghum, or millet.

1894.—What is the fourth and what is said of it? 1895.—Where and when is rice sown? 1896.—Relating to the rice plantations of Lombardy what is said? 1897.—What is the great objection to the cultivation of rice? 1898.—Caroline supposes this filtration would be advantageous to the meadow land—what is the reply? 1899.—What is said of the third species of corn?

We have run through a great variety of subjects to-day; the natural and artificial grasses, which form the two great stores of food for cattle, and the latter of which enters so beneficially into the rotation of cropping; the tuberous roots of which both man and beast equally partake; and, finally, the numerous species of grain, which afford a more solid and wholesome nourishment than any other kind of vegetable food. After such an abundant store of sustenance, were I to prolong the subject further I fear it would satiate your appetite, we will therefore reserve what remains to be said on vegetable food till our next interview.

CONVERSATION XXXI.

ON OLEAGINOUS PLANTS, AND CULINARY VEGETABLES.

Mrs. B. Among the articles of vegetable food, the oils which are extracted from plants afford one of the most valuable; nor are they of less importance in affording us light by their combustion. They are employed also in a number of manufactures, such as soap, woollens, varnishes, and perfumery.

There are, you know, two kinds of vegetable oil, distinguished by the name of fixed and volatile. The latter may be extracted from almost every plant; but it is used only as a perfume, or to flavor liqueurs, such as the oil called attar of roses, with which you are acquainted.

Emily. Yes; and with that of Jasmine and orange, so commonly used to perfume pomatum. In a word, the perfumer's shop abounds with these sweet-scented oils.

Mrs. B. They constitute the luxury of the sense of smelling, but are frequently prejudicial from their effect on the nerves; and some few of them are employed medicinally. But the essential or volatile oils are not those most deserving our attention: the fixed oils are of much higher importance, and are extracted from a class of plants, hence called oleaginous. The oil is expressed from the seed of all these plants excepting the olive, in which it is obtained from the pericarp, or fleshy part of the fruit which surrounds the seed.

1900.—For what purpose are the oils of vegetables used, besides food? 1901.—What are the two kinds of oil? 1902.—What is said of the use and importance of volalile oils? 1903.—And of the fixed oils?

The greater part of the seeds of oleaginous plants contain albumen, and it is from this, that the oil is obtained; but when the seed has no albumen, as is the case with the poppy, it is the embryo which furnishes the oil.

In the family of the *Euphorbiaceæ*, all of which have oleaginous seeds, the embryo is of a venomous nature, and oil extracted from it would be poisonous; while that expressed from the albumen of the same plant, situated contiguous to the embryo, is perfectly innocent. Such is Bancul nut, (*Aleurites Moluccanum*,) which is remarkably mild, and is eaten by the inhabitants of the Molucca isles, as we eat hedg-nuts in Europe, while oil obtained from the embryo is an acrid poison.

Emily. Can oil be expressed from plants growing wild, or is it necessary they should be cultivated in order to supply it?

Mrs. B. Some small quantity may be obtained from thistles: the stone pine, and plum-tree of Briancon also yield it; but it is the seed of the beech-tree alone which affords it in sufficient abundance to make it worth the labor of obtaining. The forest of Villers-Coterot, in France, produces a great quantity of this oil. It is less liable to become rancid than any other, and, on this account, is often mixed with olive oil, which is to be exported to America or any other distant part; but it all passes under the name of olive oil.

The fixed oils obtained by cultivation may be ranged under three heads: first, olive oil, the produce of warm climates; secondly, nut oil, that of temperate climates; and, thirdly, oils obtained from the seeds of oleaginous herbs.

The olive-tree originally came from Syria. That plant, as well as the vine, was brought to Marseilles by the Phocians; and, at the present day, it is cultivated on all the shores of the Mediterranean. It is a tree of very slow growth, but of long duration: it can support a temperature as low as eight or ten degrees of Fahrenheit, provided the air be dry; but, if accompanied with humidity,

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1904.—From what is the oil in oleaginous plants obtained, and what exception to this does the poppy make? 1905.—What is said of the Bancul nut? 1906.—From what wild plants may oil be obtained? 1907.—What is said of the oil of the beech-tree nut? 1908.—Under what three heads may the fixed oils obtained by cultivation be classed?

one or two degrees below the freezing point, proves fatal. The plant, however, may recover, if cut down to the roots, a little below the surface of the soil; it then strikes out fresh shoots, forming five or six young trees.

Manure used for olive-plantations should be of a dry nature; and it is necessary to heap up the earth over the roots, to keep them well covered.

Caroline. These roots must be naturally very superficial; for, notwithstanding the care that is taken to cover them with earth, I have observed that they are continually making their appearance above ground.

Mrs. B. It is rather the rugged and tortuous base of the stems which you have observed, and which wear the appearance of roots.

There are several varieties of olive-trees. Those of the plantations about Nice, afford us oil perfectly white and limpid, and equally free from either smell or taste: it is held in very high estimation in northern countries, where the natural taste of oil is disliked, probably from its being associated with that of rancidity; but, in the countries which produce oil, where, being eaten fresh, it is very seldom rancid, the oil which partakes of the flavor of the fruit is preferred.

The fruit should be gathered, not shaken from the tree in order to prevent their being bruised, and the oil expressed as soon as possible afterwards, otherwise there is danger of rancidity. In Spain, and other countries where feudal tenures still exist, the olive-mills belong to the lords of the land, and the peasantry are obliged to wait their turn for their olives to be pressed, to the great detriment of the produce. This is, perhaps, the only harvest which is gathered in about Christmas, the fruit not being ripe earlier.

Olives begin to be cultivated at 43° of latitude: in tropical climates, they will grow at two hundred fathom above the level of the sea.

Emily. And, in temperate climates, where the olive ceases to grow, the walnut replaces it.

Mrs. B. Yes; but the oil obtained from the walnut is far inferior to that of the olive, having both color, smell,

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1909.—What is said of the olive tree? **1910.**—What is said of manure for olive-plantations? **1911.**—What is said of the oil from the plantations about Nice? **1912.**—How should the fruit be gathered? **1913.**—Where will olives grow?

and flavor, qualities which are not esteemed in oils. The walnut-tree succeeds better in a northern than southern aspect; for, as the young shoots are very liable to suffer from a white frost, it is desirable that their vegetations should be retarded till the spring is so far advanced, that there will be little danger of their encountering that evil. This tree grows remarkably well at the foot of a mountain, on account of the depth of soil produced by the quantity of earth washed down.

The cultivation of oleaginous herbs enters into the course of cropping: they exhaust the soil almost as much as grain, on account of the number of seeds to be ripened; they require, therefore, a considerable quantity of manure. These herbs are generally of the cruciform family, containing azote, an element of the animal kingdom which forms excellent manure: so that, after the oil is expressed, the cake which remains serves to restore the exhausted soil. Rape is a species of cabbage with thin roots, whose seeds yield excellent oil.

The poppy is an oleaginous plant, with white, scarlet, and violet flowers, while the seeds are white or black. They yield oil, perfectly innoxious and wholesome, though drawn from the same plant which supplies us with opium.

Caroline. I confess I should always be apprehensive of its being adulterated with some mixture of its poisonous neighbor. Is not flax, also, an oleaginous herb?

Mrs. B. Yes. It is, however, chiefly cultivated for its stalks, from which linen thread is fabricated; but its seed also yields the oil we call linseed-oil. It is much used in the art of painting. Hemp is of the same description. There are some few oleaginous herbs of the leguminous family, such as the subterranean Arachis, (*Arachis hypogæ*,) a plant we derive from America, which has the singular property of ripening its seeds under ground. This plant requires a loose sandy soil in order that the lower branches may be enabled to bury themselves in the ground. In a state of cultivation, the earth should be heaped over them, as is done with potatoes. The upper

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1914.—What is said of the oil from the walnut? **1915.**—Where will the walnut tree best grow—why? **1916.**—How do oleaginous herbs affect the soil? **1917.**—What is said of the poppy? **1918.**—And of flax and the oil obtained from its seed? **1919.**—And what is said of the subterranean Arachis?

branches, which blossom in the air, ripen no seed; while the lower lateral branches, which burrow in the earth, develope no regular blossom, that is to say, have no petals; but the stamens and pistils bring the seeds to perfection.

Among the objects of cultivation, the vegetables raised in our gardens for culinary purposes form a class of considerable interest.

Caroline. In our choice of these, we must be regulated by the palate.

Mrs. B. Principally, no doubt; but modified by other circumstances, such as soil, climate, &c. Plants of a fibrous, woody nature are too tough to be either palatable or digestible. Those which are acrid, or very bitter, must equally be rejected. A powerful flavor is also objectionable; and, on the other hand, great insipidity will not gratify the palate. Here, then, are many causes of exclusion, but some of them admit of remedy.

Plants of an acrid nature may be eaten young, before the acridity is well developed, especially if the most delicate parts be chosen, which are those that have been least exposed to the light. Thus the receptacle, or what is commonly called the bottom of the artichoke, and the internal part of the bractæ, are mild and pleasant to the taste when young.

Emily. And asparagus we eat as soon as the young shoots appear above ground.

Caroline. And do we not even find the taste of rhubarb in tarts delicate and pleasant, when the plant is very young, while, when full grown, it is so repugnant to us?

Mrs. B. It is true that rhubarb requires to be eaten very young, in order to be palatable; but it is the ribs of the leaves which we make into tarts, while that part of the plant taken medicinally, and which is so pungent and disagreeable, is the roots; and it must grow in a warmer climate to have its medicinal properties developed. That which we import from Turkey is grown either in Tartary or at the foot of Mount Caucasus.

All strong vegetable flavors, even that of the Prussic acid, which is one of our most deadly poisons, may be rendered agreeable to the palate, and perfectly innocent,

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1920.—In the cultivation of vegetables what ones should be rejected? **1921.**—How can plants of an acrid nature be used? **1922.**—Of rhubarb what is said? **1923.**—And of the imported rhubarb? **1924.**—How may all strong vegetable flavors be used? **1925.**—From what is Prussic acid obtained?

if taken in very minute portions, and mixed up with considerable quantities of insipid food. The Prussic acid is found in the kernels of peach-stones and in bitter almonds, but in very small quantities; and yet one or two of these is sufficient to communicate an exquisite flavor to a dish of cream or pudding.

Celery belongs to the class of Conium, or hemlock, the poison which caused the death of Socrates; but its pernicious qualities will not be developed, and it will grow white and tender, if the stems be kept covered with earth.

Emily. Insipid plants should, then, on the contrary, be fully exposed to the light and air, in order to bring forth what little flavor they contain?

Mrs. B. Yes; and they should be eaten only when full grown. Great insipidity is not wholesome, any more than a very strong flavor: the one produces too great excitement in the digestive organs, the other does not afford them sufficient stimulus.

Emily. Both these defects, I should think, might be corrected, by cooking vegetables of such opposite qualities together.

Mrs. B. It is with this view that thyme, sage, mustard, onion, and even garlic, are used as seasoning for food of an insipid nature; and sugar and spices are most useful auxiliaries for such a purpose.

Caroline. Salt seems to be the most universal of all ingredients to season cookery.

Mrs. B. I omitted mentioning it, because it was not of the vegetable kingdom.

There are no less than fifty-four species of plants, which may be considered as belonging to the class of culinary vegetables. These are derived from thirty-nine genera and seventeen families; and produce above five hundred varieties.

Among these families, the Cruciform supplies our table with the greatest number of dishes. It derives its name from the blossom having four petals in the form of a cross.

1926.—Of celery what is said? **1927.**—What comparison is made between the effects of plants of great insipidity and of very strong flavor? **1928.**—How are these different plants made fit for use? **1929.**—How many varieties, families, genera, and species of plants are there belonging to the class of culinary vegetables? **1930.**—From what does the Cruciform family derive its name, and what is said of it?

Azote is found in this family alone, and it communicates to the vegetables a strong flavor and often an offensive smell. The various species of cabbages belong to it, such as the common cabbage, the curled cabbage, broccoli, cauliflowers, turnips, radishes, water-cresses, and sea-kale.

Caroline. Do you include turnips and radishes among the species of cabbages?

Mrs. B. Their leaves and blossoms are of the same description; but the appearance of the vegetables on table, I confess, is totally different; and no wonder, for in the one it is the leaves we eat, in the two others the roots.

Caroline. The leaves of the turnip, it is true, would be too strong and pungent for our palate. They are relished by sheep and cattle; and the root, which is more delicate from not being exposed to the light, is better suited to our taste.

Emily. The roots of radishes are, however, so strongly flavored, as to be disagreeable, unless eaten very young. In the cauliflower it is the blossom, and not the leaves, that we eat.

Mrs. B. The head of the cauliflower has, it is true, much the appearance of a blossom, but it consists only of numerous ramifications of the peduncles, or flower-stalks, which not having sufficient space to grow in, adhere together, and form the white mass which we esteem as a very favorite dish of vegetable food.

Emily. But the cauliflower is rather of an insipid than of a pungent nature, and requires salt to season it.

Mrs. B. Its flavor is not strong if the head only be eaten; but the smell and taste of the water in which it is boiled is extremely offensive, and that of the vegetable itself is often unpleasant, when served at table.

Emily. I know scarcely any odor more disagreeable than that proceeding from a plantation of decayed cabbages, in which the azote is fully developed.

Mrs. B. When the cauliflower is allowed to attain its natural growth, or, as the gardeners express it, is left to run to seed, the flower-stalks lengthen and spread, and the

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1931.—Of azote what is said; and of the various species of cabbages named? **1932.**—Caroline asks, if turnips and radishes are included among the species of cabbage—what is the answer? **1933.**—Of the head of the cauliflower what is said? **1934.**—And of the flavor of it—also, of the water in which it is boiled? **1935.**—When it runs to seed what is said of it?

blossoms are developed at their extremities. Broccoli is of a similar nature: the pedunculi amalgamate and form a head; but it is of a green color, because not so closely enveloped in leaves and sheltered from the light as the cauli-flower. The small tender grain which is deposited upon it, consists of the embryo of blossoms which cannot be developed, owing to the quantity of nourishment of which the stalks deprive them.

The Leguminous family affords us four species of culinary vegetable,—peas, beans, lentiles, and kidney-beans; of some of these we eat only the seeds; in others, such as the kidney-bean and sugar-pea, the pod or pericarp are also eaten.

The family of Cucurbitacæ supplies us with cucumbers, pumpkins, and melons: the two first are rather arbitrarily denied the name of fruit, and are ranked as culinary vegetables, merely on acconnt of the saccharine principle not being developed in them.

This family is distinguished by a bitter principle contained in one of its species, the Colocinth: it is so strong as to be taken only medicinally.

From the Umbelliferous family we obtain carrots, parsley, lettuces, and hemlock. The narcotic principle exists throughout this family: in hemlock it is so powerful as to constitute a poison; but in most of the other species, it exists in such small quantities as not to be deleterious.

The family of Solanum gives us the Potatoe, Tomata, and the Belladonna, celebrated for the poison it contains.

Caroline. And yet nearly akin to the potatoe, which is of so innocent a nature!

Mrs. B. That is true of the tubercle we eat, but the fruit of the plant is of an acrid nature: you may probably have been warned, in your childhood, of the poisonous properties of the small green tubercles which grow on the branches.

The family of Fungi supplies us with the mushroom, a vegetable of a most delicate and exquisite flavor; but as

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1936.—Of Broccoli what is said? **1937.**—What four species of culinary vegetables does the Leguminous family afford us? **1938.**—With what does the family of Cucurbitacæ furnish us, and what is said of them? **1939.**—How is this family distinguished? **1940.**—What is said of the Umbelliferous family, and with what does it furnish us? **1941.**—Of the family of Solanum what is said? **1942.**—What account is given of the mushroom?

those species which grow wild are generally of a poisonous quality, it is important that we should learn how to produce such as are known to be innoxious. For this purpose, the white filaments commonly called the spawn of mushrooms, should be cut in pieces and sown in a hot-bed. Whether these filaments consist of shoots, runners, or seeds of mushrooms, has not been well ascertained; but when spread over a hot-bed, and sheltered from the open air, either under a shed or in a cellar, they will germinate. In Paris, mushrooms are raised in the Catacombs; and I know no place where they are produced in such abundance, or sold so cheap. The spawn should be sown in December, covered with a little earth and a litter of straw, then watered; and after a short time, if the litter be raised, the mushrooms will be seen growing beneath it.

These are some of the principal families from which we derive our vegetable food: I will not attempt to go through the whole seventeen,—it will be uselessly trespassing upon your patience.

I have now, I believe, imparted to you the whole of my little stock of botanical knowledge. The source from which I drew it was rich and copious; but I am too well aware of my incapacity to do justice to the subject, not to shrink at the apprehension of having disfigured those lessons which afforded me such a delightful source of instruction; which taught me to investigate, with wonder and admiration, the beautiful organization of the vegetable creation, and raised my mind, with increased fervor of gratitude, towards their bountiful Author.

1943.—Where is it raised in Paris? 1944.—When should the spawn be sown? 1945.—How should it be covered?

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PLATE I.

THE COMMON PEA.

Pisum vulgaris; Leguminous family, Dicotyledon.

a,	Stem.
b b,	Stipula.
c c,	Petiole, or common leaf stalk.
d d,	Folioles of the compound leaf.
e e,	Apex of the leaf.
f f,	Tendril, terminating the petiole of the leaf.
g g,	Peduncle or flower stalk, springing from the axilla, and dividing it into two pedicels.
i i,	Pedicels.
k k,	Axilla of the leaf.
l,	The flower.
m m,	The calyx.
n n,	The corolla.
o,	The standard or superior petal.
p p,	The two wings or lateral petals.
q,	The carina, or two lower petals soldered together, seen interiorly.
r,	The torus, or base of the flower.
s,	The stamens, nine of which are half soldered together by their filaments.
s^1,	The tenth stamen free.
t t,	The anthers.
v u w,	The pistil—*v*, the ovary; *u*, the style; *w*, the stigma, bearded.
x,	The fruit or pod, of which a portion has been removed in order to show the seeds.
y y,	The seeds attached to the upper suture of the pericarp.

z z, Firmeules or ligatures attaching the seeds to the pericarp.

y^1, A seed detached.

y^2, The cicatrice.

y^3, The seed split open, showing the embryo plant and the two cotyledons.

A, The radicle.

B B, The two fleshy cotyledons.

C, The plumula.

[illegible]

[illegible] in which a person has been [illegible]

[illegible] attached to the upper surface of [illegible]

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PLATE II.

WILD TULIP.

Tulipa sylvestris; family Liliaceous, Monocotyledon.

a, Stem.
b, That part of the stem which forms the peduncle of the flower.
c c c, Leaves.
d d, Flowers with six pieces disposed in two rows, bearing the name of Perigone.
e, Torus, or base of the organs of the flower.
f, Filaments of the stamens bearded at their base.
f^1, The anthers.
g, The pistil composed of the ovary and the stigma, having no style.
g^1, The ovary.
g^2, The stigma crowning the ovary, composed of three cells.
C c, The pistil enlarged and grown into a fruit.
C c^1, The cut open, to show the three cells, separated by partitions, and enclosing each two rows of seeds attached to the centre of each cell.
h, A separate seed.
h^1, The same cut through lengthwise, to show the spermoderm, the albumen, and the embryon.
i, The spermoderm.
k, The albumen.
l, The embryon.

l^1 The embryon alone, showing it to be of one piece or monocotyledon.

m, The bulb.

n, The base, representing the trunk or stem.

o, The roots.

p. A lateral branch.

PLATE III.

CHINA-ASTER.

Aster Chinensis; Syngenesios family, or Compound Flower.

a	The stem
b,	A branch.
c c,	Leaves.
d,	A head not blown.
d^1,	A head in blossom.
e e,	Folioles composing the involucre.
f,	Flora leaves, approximating to the form of the folioles of the involucre.
g,	Ligulate florets situated around the disk.
g^1,	A single floret remaining on the head, all the others being taken off.
h,	Tubular florets situated on the disk or centre of the head.
h^1,	A single tubular floret remaining on the disk.
g^{11},	A ligulate floret magnified. E
i,	Tube of the calyx soldered on the ovary.
k,	Edges of the calyx terminating in layers or pappus.
l,	Ligulate petal terminating in fine teeth.
m,	Two stigmas.
h^{11},	A tubular floret magnified.
i^1,	Tube of the calyx soldered on the ovary.
k^1,	Pappus crowning the calyx.
l^1,	Tubular petal terminating in fine teeth.
$m,^1$	Stigmas.
n,	Upper part of the style bearing the stigmas.
n^1,	The same magnified.
n^{11},	The lower part of the style.

m^{11}, The two stigmas enlarged to see the sweeping hairs.

l^{11}, Tubular petal split lengthways and spread open.

o o, The fine filaments of the stamens.

p p, The fine anthers soldered together, and forming a tube.

q, The fruit entire crowned by the pappus.

r, The fruit magnified.

s, The cicatrice, by which the fruit adheres to the receptacle.

t, The border of calyx magnified, showing a single hair truncated, inserted in a ring of teeth, the rest of the hairs being pulled off.

u, The embryon, in which may be distinguished the radicle and the two cotyledons.

x, Receptacle of the florets.

Pl. IV.

Fig. 1.

Fig. 3.

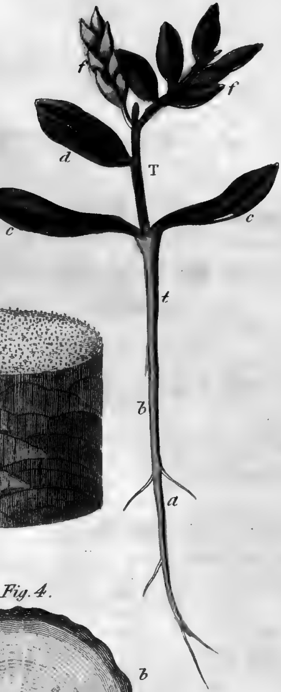

Fig. 2.

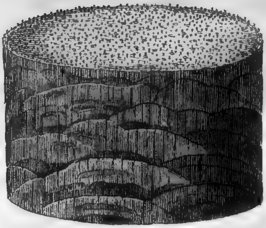

Fig. 4.

Fig. 5.

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PLATE IV.

Fig. 1.

GERMINATION OF A MONOCOTYLEDON, OR ENDOGENOUS PLANT.

The *Scheuchzeria palustris*,

a, Pivot or radicle.
b b, Accessory roots shooting from the bottom of the stem.
c, Cotyledon or first leaf.
d d^1, Second and third leaves, called primordial.
c c, Common leaves of the plant.

Fig. 2.

HORIZONTAL SECTION OF THE STEM OF A MONOCOTYLEDON, OR ENDOGENOUS PLANT.

Yucca aloifolia.

Showing the scattered fibres which compose the wood, having neither bark, pith, medullary rays, nor distinct layers.

Fig 3.

GERMINATION OF A DICOTYLEDON, OR EXOGENOUS PLANT.

Daubnentonia punica.

a, Radicle slightly branching.
b, Neck or vital point between the root and the stem.
t, Portion of the stem below the cotyledons.
T, Portion of the stem above the cotyledons.
c c, Two opposite cotyledons.
d, A simple primordial leaf.
f f, Common leaves.

Fig. 4

VERTICLE SECTION OF THE STEM OF A DICOTYLEDON, OR EXOGENOUS PLANT.

The *Oak*.

a b, The bark, composed of the verticle layers *a*, and the internal bark *b*.
c d e, The wood, composed of the alburnum or young wood, *c*, the perfect wood *d*, and the pith *e*.
The circular zones represent the layers of wood, and the lines diverging from the centre the medullary rays.

Fig. 5.

A BRANCH TURNING ITS LEAVES TOWARDS THE LIGHT.

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